AGRICULTURAL ENGINEERING

SEPTEMBER • 1953

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Engineering Design of a Livestock Physical Plant

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Method of Determining the Dielectric Properties of Grain

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Evaluating the Need of Irrigation in Humid Areas

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New Data on the Resistance of Grains and Seeds to Air Flow

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Efficiency and Economy of Horizontal Self-Feeding Silos

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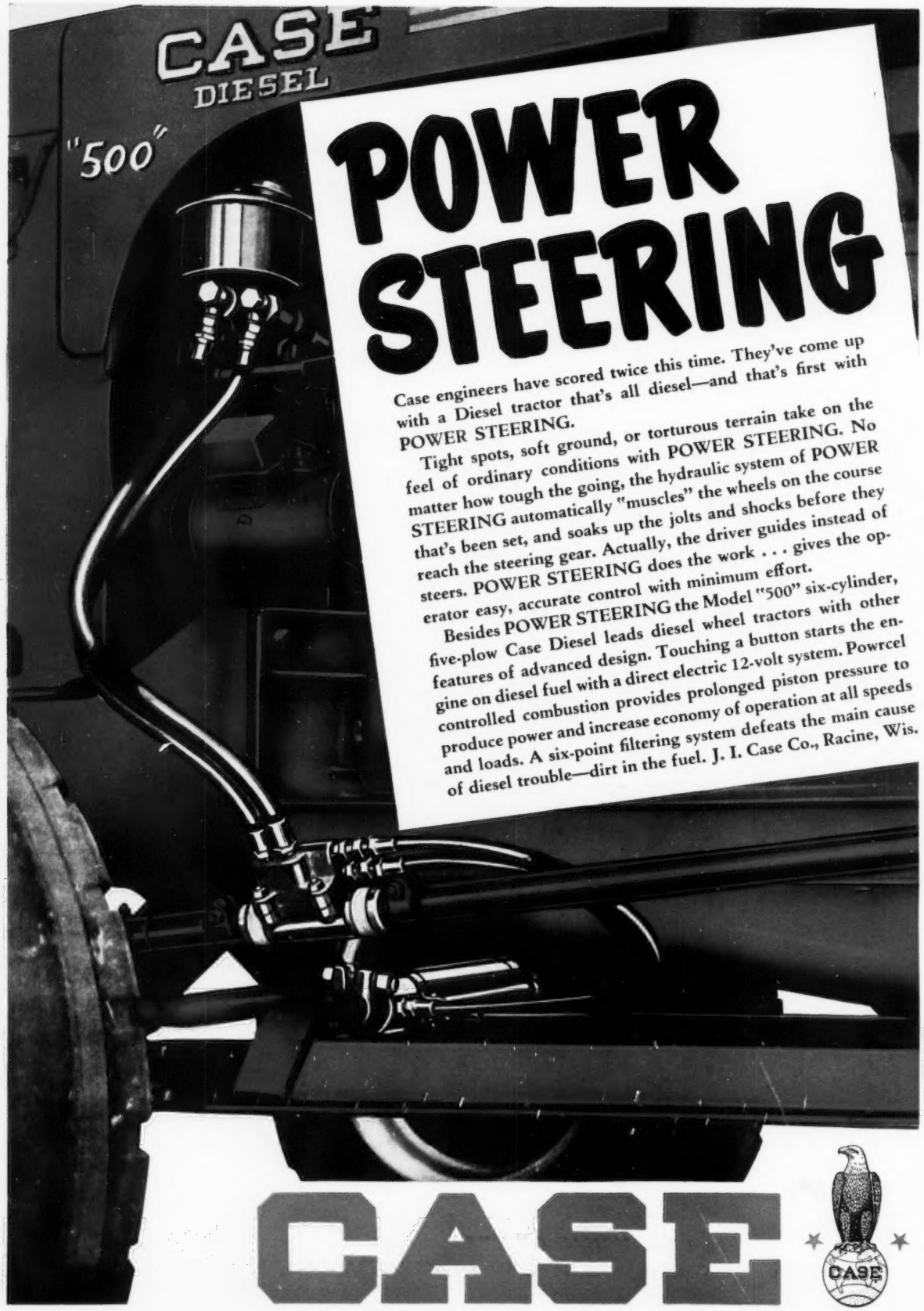

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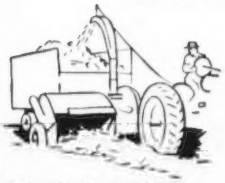
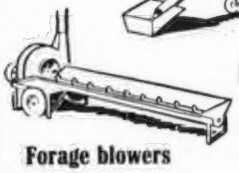


Forage harvesters

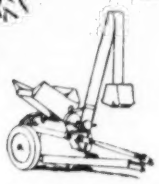
Grain loaders



Forage blowers

Spreaders

Post hole diggers



Feed grinders

AGRICULTURAL ENGINEERING

Established 1920

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AGRICULTURAL ENGINEERING is owned and published monthly by the American Society of Agricultural Engineers. The editorial, subscription and advertising departments are at the executive office of the Society, 505 Pleasant St., St. Joseph, Michigan (Telephone: 3-2700).

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ADVERTISING REPRESENTATIVES

Chicago 2: DWIGHT EARLY & SONS
100 North LaSalle St.
Tel. CEntral 6-2184

New York 17: BILLINGSLEA & FICKE
420 Lexington Ave.
Tel. LExington 2-3667

SUBSCRIPTION PRICE: $4.00 a year, plus an extra postage charge to all countries to which the second-class postage rate does not apply; to ASAE members anywhere, $3.00 a year. Single copies (current), 40 cents each.

POST OFFICE ENTRY: Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103 Act of October 3, 1917, authorized August 11, 1921.

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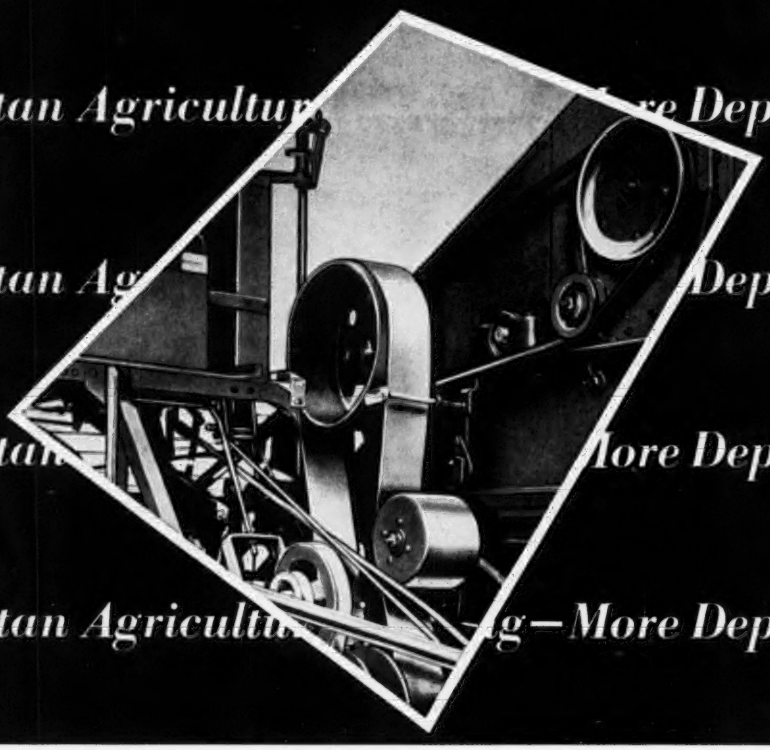
Manhattan Agricultural Belting—More Dependable



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LONG LIFE, STRENGTH, FLEXIBILITY, and uniform performance under all operating conditions — these are the qualities of dependability which manufacturers of farm equipment get when they specify "Manhattan Agricultural Belts."

Manhattan's investment of 60 years of research in the development of agricultural rubber products has produced the most reliable and economical belts available today. Made for all power applications, Manhattan Agricultural V-Belts and Condor Whipcord Endless Belts are designed to meet the most rigid modern requirements of farm equipment manufacturers.

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R/M

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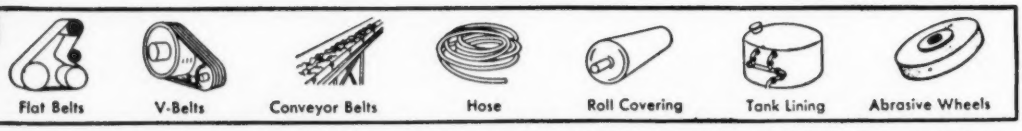

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clean dairy stalls, milk cows,
feed livestock, other chores.
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GARDENER. Must be handy man.
Steady job. 1006 Latimer st. 8 A. M.
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opportunity for right man. Bryn
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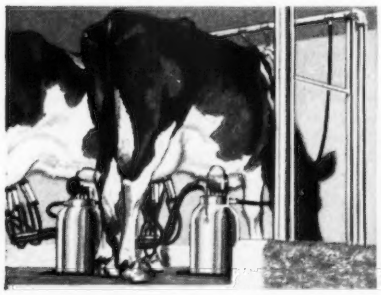
Armco Steels can fill this job!

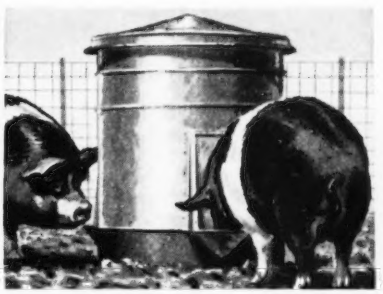
When you add up the work-hours saved by modern sheet steel dairy and barnyard equipment, it amounts to having an extra man around the farm. And when equipment is made of Armco Special-Purpose Steels, farmers can be sure of extra value, less maintenance and longer service life.

For example, Armco PAINTGRIP Steel cuts down on maintenance costs because it saves painting time. Used in farm buildings and equipment of many kinds, this special zinc-coated steel has a Bonderized surface that grips and holds paint. Tests show paint life is several times longer than on regular galvanized steel.

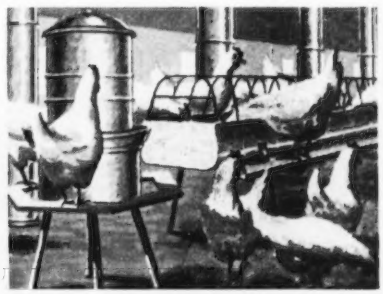
When you see the Armco trademark on any sheet metal parts of farm equipment, you know the manufacturer has used a *special-purpose steel* to give the farmer long, low-cost service.



Automatic milkers save hours of hard, costly hand milking. The Armco Steels in milkers, stanchions and other dairy equipment give long service, reduce the number of hours spent in cleaning and maintenance.



Automatic hog waterers provide livestock with a constant supply of clean water—summer and winter. When the waterer is made of Armco Special-Purpose Steels, farmers get longer service, with less maintenance.



Poultry equipment made of Armco ZINCGRIP doesn't rust and fail prematurely because its protective zinc coating does not flake or peel in fabrication. This means extra-long service with little or no upkeep.

ARMCO STEEL CORPORATION

MIDDLETOWN, OHIO • THE ARMCO INTERNATIONAL CORPORATION, WORLD-WIDE

Photo courtesy Massey-Harris Co., Ltd., Toronto, Ontario, Canada.

Chrysler powers 70-acre-a-day combine

"'King-size' for today's 'king-size' grain crops" . . . that's one way you might describe this new self-propelled combine shown here hard at work in a wheat field. It has a sixteen-foot, hydraulically controlled auger table and cutting bar which picks up and cuts in any of three widths. Extra-capacity rub bars and straw walkers help assure more complete threshing. Covers plenty of territory with maximum speed of more than fourteen miles per hour, hydraulically controlled through variable speed drive.

To power this combine, Massey-Harris uses the mighty Chrysler Industrial Model 8 Engine with 250 cubic inches displacement. In other Massey-Harris combines the slightly smaller Industrial Model 5 Engine is used. By so doing, this manufacturer makes certain that his combines will give top-notch performance—the kind farmers can depend upon to get in their valuable crops year after year.

Manufacturers select Chrysler Engines *equipped* to meet their needs. For example, they can have engines with standard or gear-driven front ends (with magneto or hydraulic pump drive), twelve or twenty-four volt electrical systems, standard, gýrol Fluid Coupling or torque converter transmissions.

They find too that Chrysler-Industrial Power is not expensive. Production-line methods adapted to specialized industrial engine building provide a custom-built engine at mass-production prices.

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Industrial Engines

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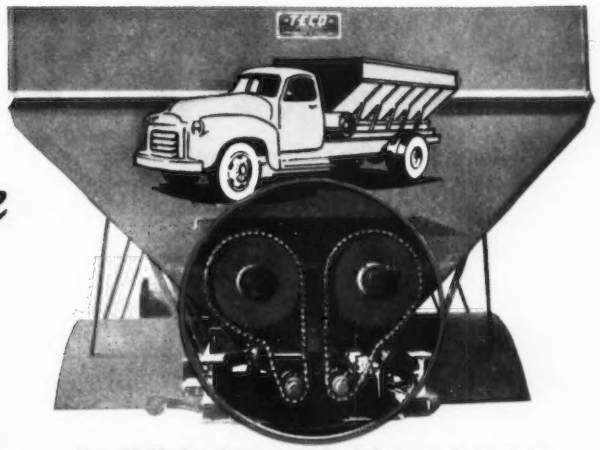
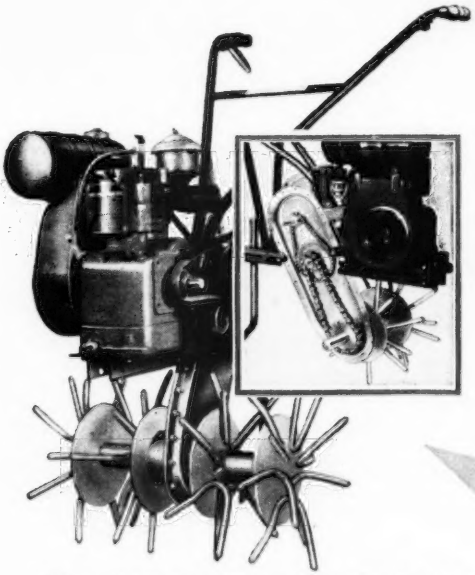


New TS-50 Twin-Screw type Feed Bed manufactured by Thompson & Gill, Inc. features *positive* twin screw action, amazing *simplicity* of design and *fewer working* parts. The twin screws are driven by efficient, dependable Diamond Roller Chains.

DIAMOND ROLLER CHAINS



This garden tiller produced by Merry Manufacturing Co. tills and mulches to 10" deep in soil or rocky ground. It's built to withstand shock loading. Diamond Roller Chains provide positive non-slip power to drive the tined rotors.

• Non-slip Diamond Roller Chains provide the extra dependability and long life vital to outstanding performance. Long, wide use on America's foremost agricultural machinery is proof of Diamond Roller Chains' superior *performance, durability,* and the *greater economy* they provide wherever power must be transferred.

A few Diamond Roller Chain advantages:

- ☆ **Great uniform strength—yet light weight and small size.**
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- ☆ **Easily adapted to long or short centers or to driving several shafts from the same power source.**
- ☆ **Efficiency of 98 to 99% at high or low speeds.**

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To increase the fatigue resistance of Diamond Chains, link plates have been specially processed, and chain rollers and other parts have been shot-peened since 1944.

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BY FARMING THE CAT* TOOL BAR WAY!

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5-minute change from dozer to subsoiler!

1. Just remove cotter keys and pull 4 pins to drop blade.
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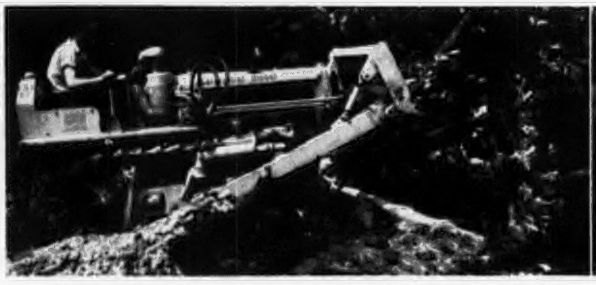

CLEAR LAND WITH A CAT TOOL BAR DOZER . . . clear your waste land and fence rows with your own farm power, and save. Cat Tool Bar Blade costs only $268.00† . . . about ¼ the price of ordinary dozers.

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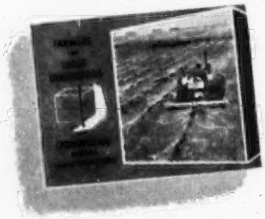

FREE: Tool Bar Farming Booklet tells how you can get the most out of your farm by working **all 3** dimensions! Write Caterpillar or see your Dealer for your free booklet.

†Prices F.O.B. Peoria, Illinois. Subject to change without notice. Tool Bars and tools sold separately.

Caterpillar Tractor Co., Peoria, Illinois

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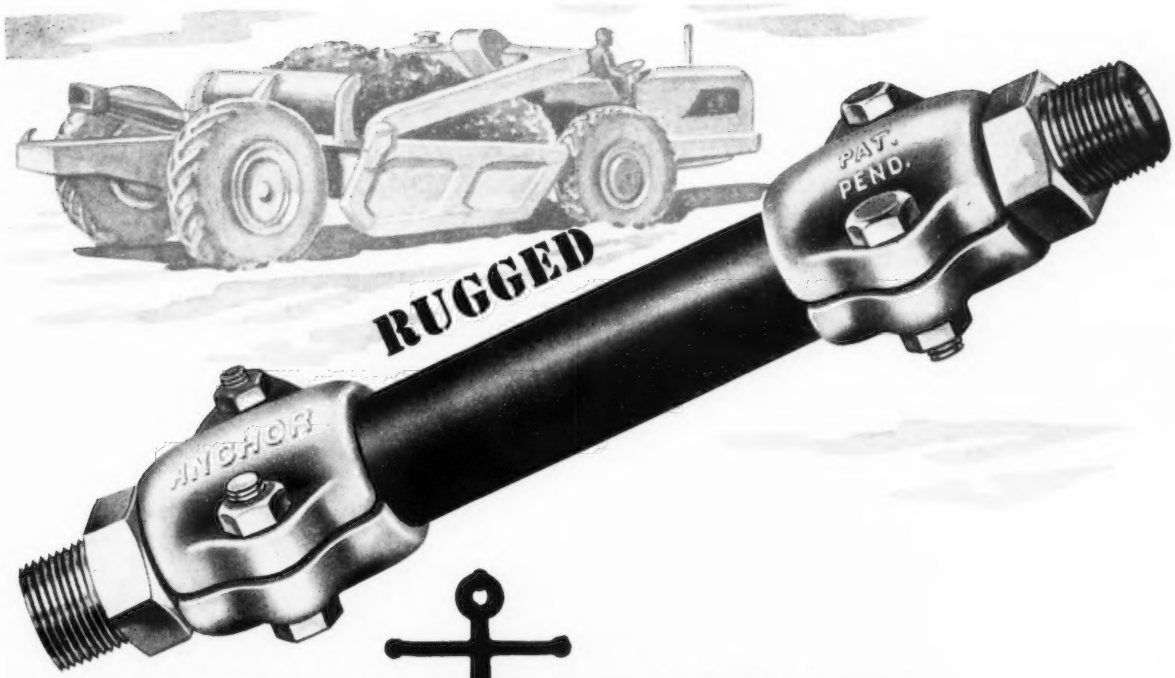

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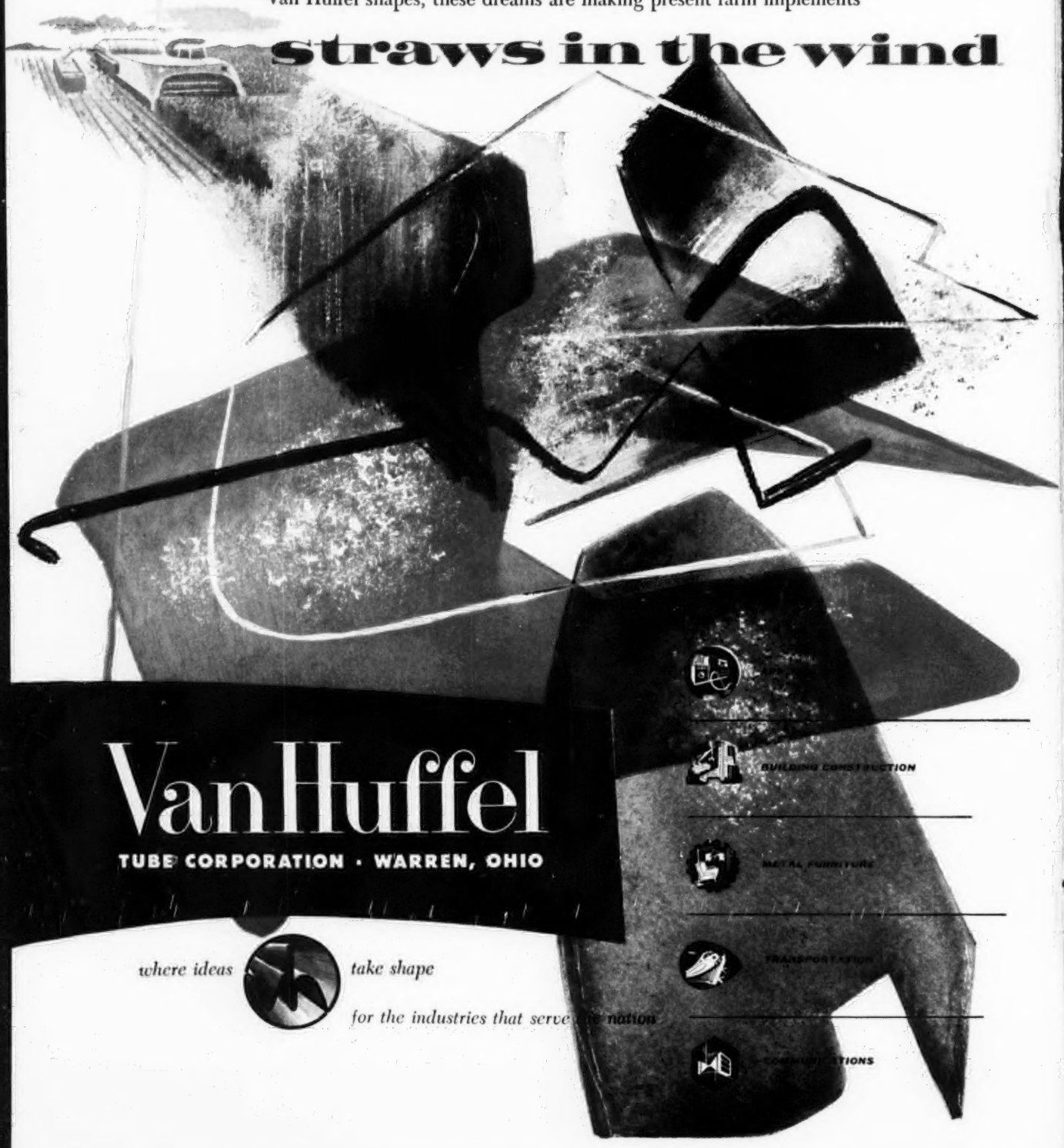
straws in the wind



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TUBE CORPORATION · WARREN, OHIO

where ideas *take shape*

for the industries that serve the nation

WHAT'S YOUR UNIVERSAL JOINT PROBLEM ?

If you're building implements like these, BLOOD BROTHERS offers great advantages

PRODUCT	BLOOD BROTHERS Universal Joints now used by leading implement manufacturers: Series	
Combines	3DR	L16S
Corn Pickers	1FR	3DR
Corn Snappers	1FR	3DR
Cotton Pickers	L6N	L16S
Diskers & Seeders	1FR	
Dusters	L6N	1FR
Elevators	K-1-C	1FR
Ensilage Blowers	K-1-C	L6N
Feed Grinders	L14N	35N
Forage Harvesters	35N	
Grain Binders	K-1-C	1FR
Hammer Mills	L14N	35N
Hay Balers	3DR	L16S
Hay Rakes	L10S	1FR
	L6N	
Manure Spreaders	L10S	1FR
Mowers	L6N	L10S
	1FR	
Post Hole Diggers	K-1-C	1FR
Potato Diggers	1FR	3DR
Rotary Weeders	K-1-C	K2R
Shredders	L14N	35N
Shellers	1FR	3DR
Snow Plows	3DR	35N
	L14N	
Sprayers	35N	3DR
	1FR	
Swathers	1FR	3DR
Tractors	K-1-C	L6N
	L6S	
Wagon Unloaders	K-1-C	1FR
	K2R	
Windrowers	1FR	3DR

Need specific information? Blood Brothers will promptly supply details on these joints—or others suitable for construction equipment, trucks and buses, industrial machinery and marine applications. Our engineering staff—backed by 43 years' experience—will gladly assist you.

TORQUE CAPACITIES at Tractor Speeds of 550 rpm.

Series	Horsepower
K-1-C	3
K2R	3
L6S	4
L6N	5
L10S	5
1FR	10
L14S	11
3DR	15.7
L16S	19
L14N	30
35N	50

You can get joints alone or assembled with fixed or slip joint shafts... with or without integral safety shields, safety clutch, clamp yokes... or with the popular, salable quick-detachable yokes.

With Safety Clutch

1FR Series

PTO Slip Assembly

L6S Series

With Integral Safety Shields

Quick Detachable

BLOOD BROTHERS machine co. ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

A Division of Standard Steel Spring Co. • Chicago Office: 122 S. Michigan

Produce them better, faster, more economically by high-strength bolting!

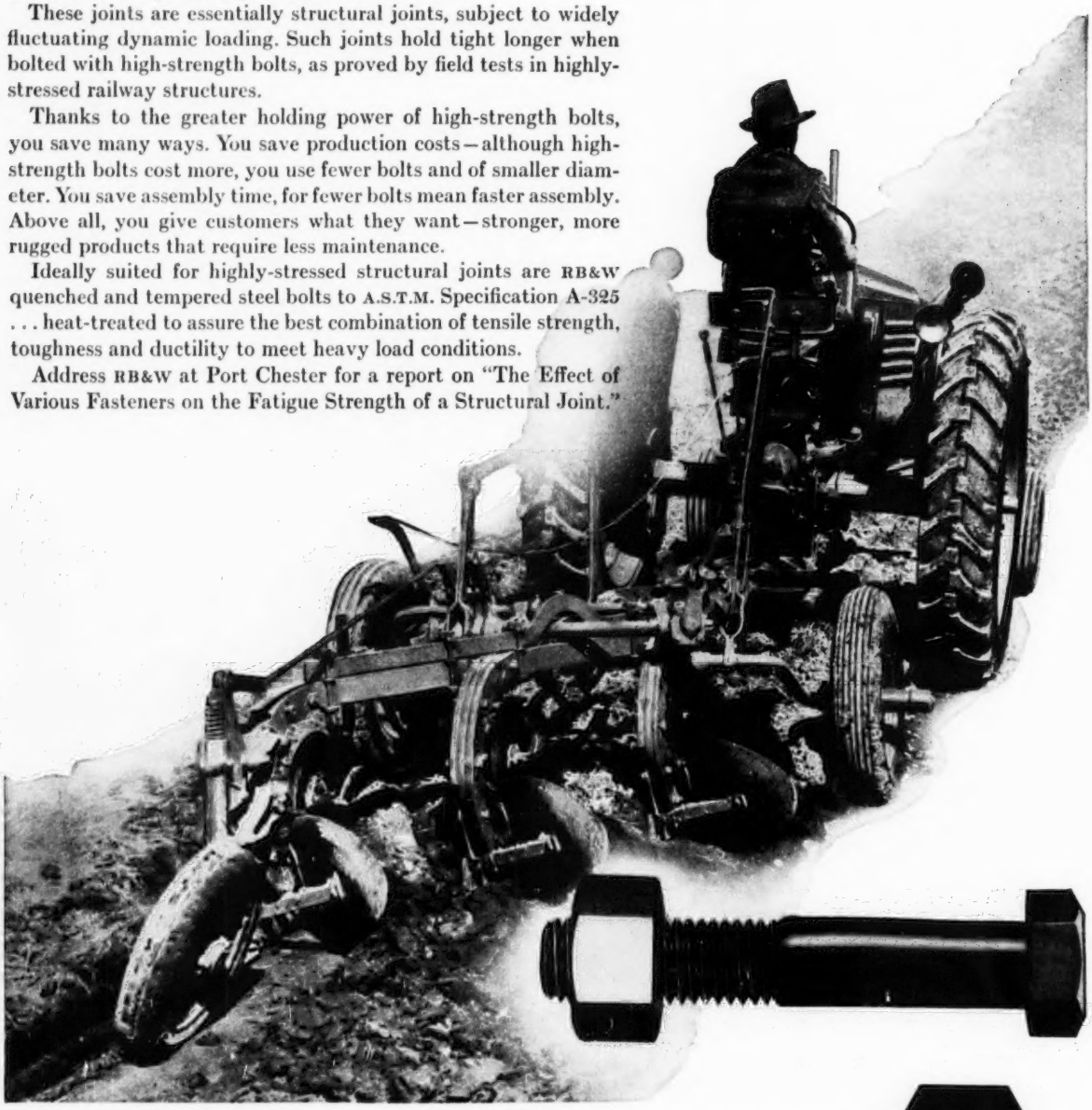
Just as the construction industry has saved money, you can too . . . by switching from your present fasteners to high-strength RB&W bolts on joints of plow and tractor frames.

These joints are essentially structural joints, subject to widely fluctuating dynamic loading. Such joints hold tight longer when bolted with high-strength bolts, as proved by field tests in highly-stressed railway structures.

Thanks to the greater holding power of high-strength bolts, you save many ways. You save production costs—although high-strength bolts cost more, you use fewer bolts and of smaller diameter. You save assembly time, for fewer bolts mean faster assembly. Above all, you give customers what they want—stronger, more rugged products that require less maintenance.

Ideally suited for highly-stressed structural joints are RB&W quenched and tempered steel bolts to A.S.T.M. Specification A-325 . . . heat-treated to assure the best combination of tensile strength, toughness and ductility to meet heavy load conditions.

Address RB&W at Port Chester for a report on "The Effect of Various Fasteners on the Fatigue Strength of a Structural Joint."



RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

RB&W
THE COMPLETE QUALITY LINE

Plants at: Port Chester, N. Y., Coraopolis, Pa., Rock Falls, Ill., Los Angeles, Calif. Additional sales offices at: Philadelphia, Pittsburgh, Detroit, Chicago, Dallas, San Francisco. Sales agents at: Portland, Seattle. Distributors from coast to coast.

108 YEARS MAKING STRONG THE THINGS THAT MAKE AMERICA STRONG

Announcing a Great New Reynolds "FIRST" Important to Farmers!

REYNOLDS Lifetime ALUMINUM CORRUGATED...48" WIDE!

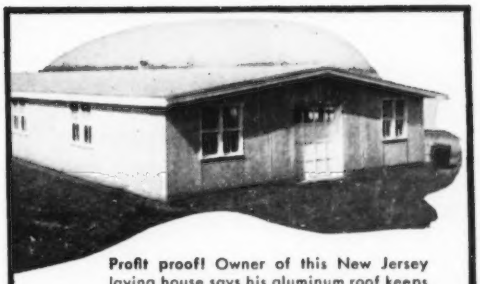
TWO 12' SHEETS COVER ALMOST A FULL SQUARE OF ROOF AREA...SAVES APPLICATION TIME AND MONEY!

Now build with aluminum in *less time*, with *less work*, at *less cost!* 50% fewer sheets to handle. 50% less loss of metal at side laps. And a better-looking job, too!

You know heat-reflecting aluminum boosts poultry and livestock profits... field tests prove it. You know rustproof aluminum saves money—needs no painting. Now you can get these proved advantages... at the lowest cost ever!

The new 48" Corrugated Sheets come in .024" (U. S. Std. 24 Ga.), 2½" pitch, embossed—and .019" (U. S. Std. 26 Ga.), 1¼ and 2½" pitch, plain and embossed. *Exclusive with Reynolds!*

See your dealer. Write for literature. Reynolds Metals Company, Building Products Division, Louisville 1, Kentucky.



Profit proof! Owner of this New Jersey laying house says his aluminum roof keeps "...egg production consistently high, bird mortality negligible."

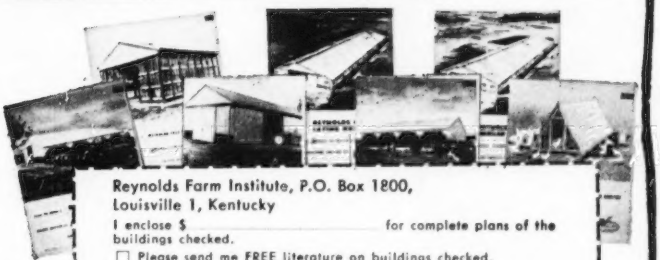
MORE LOW-COST, LABOR-SAVING BUILDINGS...COMPLETE PLANS BY REYNOLDS FARM INSTITUTE

Pole Barn 52' x 60', Pole Cattle Shed 26' x 60' and *Machinery Center 26' x 60'*... all extendable by 15' sections. *10,000-bird Broiler House, 52' x 150'* and *1,500-bird Laying House, 41' x 130'* ... shortened or lengthened by 15' sections. *Pole Corn Crib 30' x 32'*, extendable by 8' sections. Portable Range Shelter on skids, 8' x 10'.

Plans at price shown in coupon include detailed drawings, erection instructions and material lists. Or check coupon for FREE descriptive literature.

FARM INSTITUTE

SEE "MISTER PEEPERS," starring Wally Cox, Sundays, NBC-TV network.



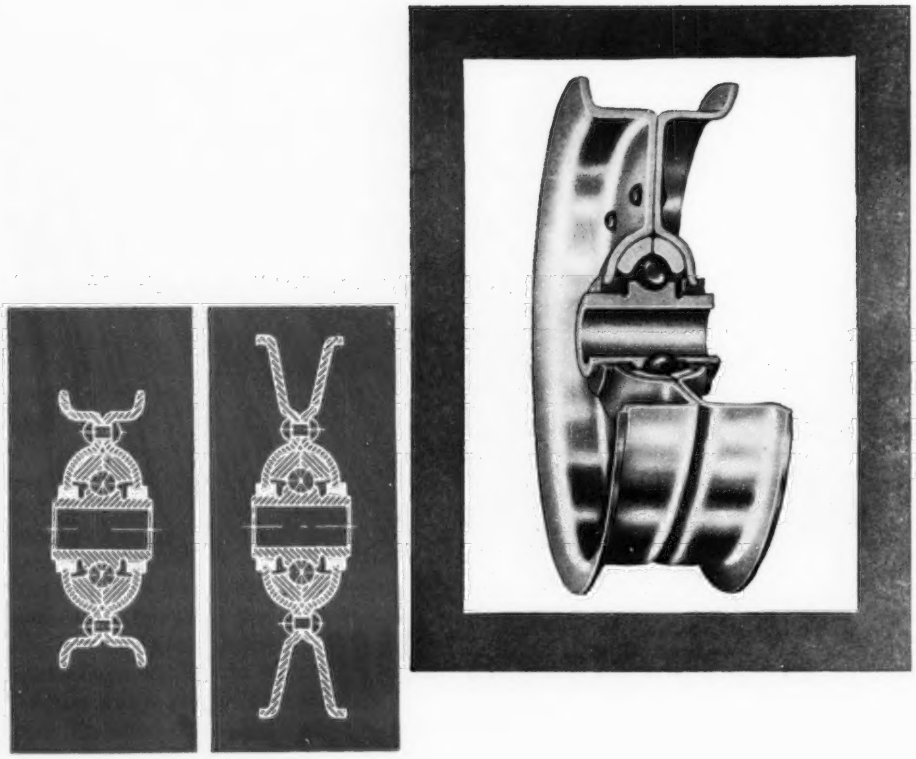
Reynolds Farm Institute, P.O. Box 1800, Louisville 1, Kentucky

I enclose $ _____ for complete plans of the buildings checked.

- ☐ Please send me FREE literature on buildings checked.
- ☐ Pole Barn ($1) ☐ Cattle Shed ($1)
- ☐ Machinery Center ($1) ☐ Broiler House ($1)
- ☐ Laying House ($1) ☐ Corn Crib (50c)
- ☐ Range Shelter (25c)

Name _____

Address _____



Economical pulley-bearing combination cuts assembly time and service problems

This revolutionary BCA *package unit* originally was designed as a chain-tightener on hay balers. It is adaptable to many agricultural applications including combines, forage harvesters, grain elevators, corn pickers and cotton pickers. The design of sheaves can be varied for use with flat belts, V-belts, or chains.

Installation problems are simplified because BCA Idler Pulley Assemblies provide both a pulley and a bearing in a single unit. The bearing requires no additional lubrication and is effectively sealed against dust and grit. The simple, rugged construction of the unit eliminates entirely field-servicing.

This is an example of how BCA engineering cooperation and design assistance helps solve problems involving ball bearings. It will be to your advantage to bring *your* problems to us.

BCA *radial, thrust, angular-contact Ball Bearings*

BEARINGS COMPANY OF AMERICA

LANCASTER • PENNSYLVANIA

HYDRAULICS FOR MOBILE EQUIPMENT

Mobile Equipment News

IMPROVES PERFORMANCE ■ CUTS COSTS

VOL. 1 — VICKERS INCORPORATED, DETROIT, MICHIGAN — NO. 3

26 MORE VICKERS DOUBLE PUMPS NOW IN PRODUCTION

OFFER MANY REAL BENEFITS WHEN TWO HYDRAULIC CIRCUITS ARE USED ON MOBILE EQUIPMENT

These double pumps are becoming increasingly popular wherever two machine components must operate simultaneously at different speeds and/or operating pressures. They also prevent all possible chance of one operation interfering with another.

TWO PUMPS IN TANDEM

These are essentially two pumps in a single housing and driven by a common shaft. Independent pressure control must be provided as there is a separate pressure outlet for each pump.

LONGER PUMP LIFE RESULTS FROM HYDRAULIC BALANCE

Like Vickers Vane Type Single Pumps, these double pumps have the exclusive Vickers "Hydraulic Balance" that eliminates pressure-induced bearing loads and results in longer pump life.

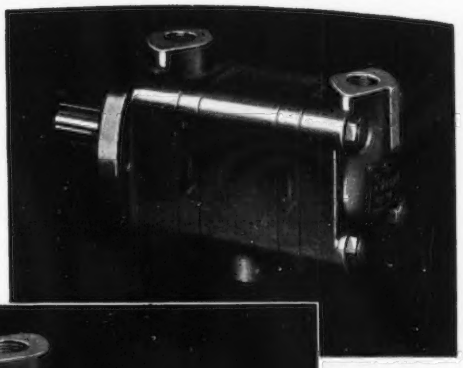
NO-LOAD STARTING

At rest and normal starting speeds, the sliding vanes are retracted; only after engine fires do vanes extend and pumping begin.

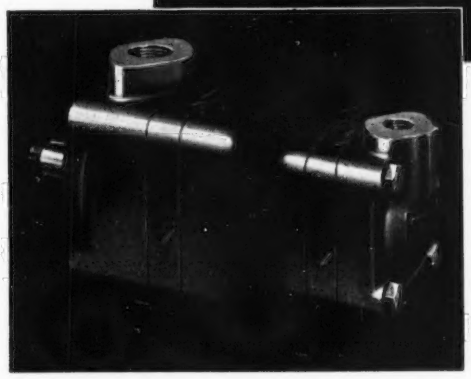
COMPACT AND EASILY INSTALLED

Greater mounting adaptability because of minimum space requirement, 3 mounting styles, optional and independent piping connection positions, shaft drive in either direction.

ASK FOR NEW BULLETIN M-5101



(Right) Series V-2200 Double Pump in 10 sizes from 3.2 to 32.6 gpm combined delivery.



(Left) Series V-3200 Double Pump in 16 sizes from 11.9 to 51.1 gpm combined delivery.

TOP PERFORMANCE THROUGHOUT PUMP LIFE BECAUSE OF AUTOMATIC WEAR COMPENSATION

Radial compensation for normal wear and temperature differentials is provided by the movement of the vanes in the rotor slots. (Wear is minimized because all parts are lubricated by the oil under pressure.)

Axial compensation is by means of a pressure plate held to optimum running clearance by pressure from the system.

Automatic compensation eliminates need for "run in" . . . efficiency is maximum the first time the pump is started. It also assures maximum delivery over a very long life and with wide oil temperature change.

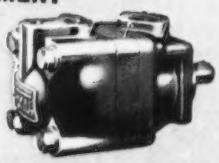
VICKERS Incorporated
DIVISION OF THE SPERRY CORPORATION
1516 OAKMAN BLVD. • DETROIT 32, MICH.

Application Engineering Offices: ATLANTA • CHICAGO (Metropolitan) CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES (Metropolitan) • NEW YORK (Metropolitan) • PHILADELPHIA (Metropolitan) • PITTSBURGH • ROCHESTER • ROCKFORD • SEATTLE TULSA • WASHINGTON • WORCESTER

6230

OTHER VICKERS DOUBLE PUMPS FOR MOBILE EQUIPMENT

(Left) Series V-4200 Double Pump in 6 sizes from 30.7 to 70.2 gpm combined delivery.



(Right) Series V-5200 Double Pump in 6 sizes from 48.8 to 89.4 gpm combined delivery.

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

THERMOPANE® INCREASES FARM PROFITS

Read what these farmers say about their experiences

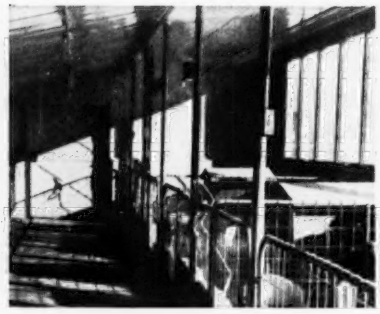
DAIRYMEN

Manville P. Cook,
Wysox, Pa.

"Plumbing in the milkhouse does not freeze, although there is no auxiliary heat. Much nicer in winter as I do not have to wear heavy clothing. There is no steaming up, as before. The windows are easy to clean and give more daylight than other glass."

Nels Hokanson,
Verona, Wis.

"Dairy barn was improved by replacing conventional windows with *Thermopane*. Better wintertime warmth, cooler in summer. Livestock health is better and working conditions improved. Attractive appearance appeals to visitors."



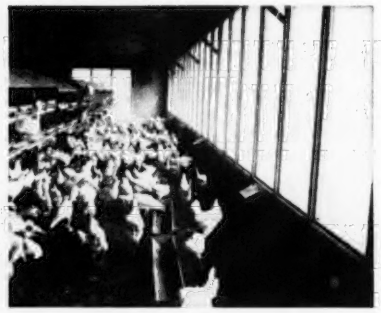
BREEDERS

Tillman Bubenzer, Conner-Prairie Farm,
Noblesville, Ind.

"Five to 10 degree winter temperature increase noted after *Thermopane* windows were placed in pig nursery. Daylighting improved 100 per cent. Relative humidity reduced 15 per cent. Pigs benefited from direct sunshine, vigor increasing through more exercise. Drier bedding made less work."

Elmer Dasenbrock,
Leigh, Neb.

"My calf loss was high before building my new calf barn. Now it is practically nil. I give much of the credit to the *Thermopane* windows. Daylighting is very good and I have excellent wintertime warmth. Condition of the bedding is good and the livestock health is definitely better."



POULTRYMEN

Verne Taylor,
Fairview, Ill.

"Obtained three dozen more eggs per hen per year in part of building glazed with *Thermopane* than in similar wing with same size windows, single glazed. Very little mortality. Drinking fountains didn't freeze, even in coldest weather. Minimum of ammonia fumes from litter, which stayed dry and hasn't been changed in two years."

Coyt M. Ingraham,
Thorndike, Me.

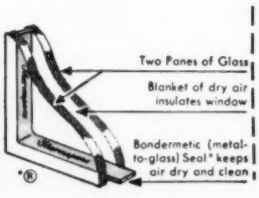
"Sunlight is one of the best things in the world for chickens and with *Thermopane* you can sure get all the sunlight there is. I think that is why I have been able to raise such good birds. My fuel costs have been greatly decreased. The broiler house is lighter and makes more pleasant working conditions."

These are just a few of the many reports received from farmers who have used *Thermopane* insulating glass. These are their own statements, not ours. Identical gains in production—identical savings—of course, cannot be expected by everyone. That is because the benefits received result from many factors, which vary by climate and local conditions. But these reports are assurance of good results—assurance of conditions conducive to increased production and better livestock health—assurance that you can recommend *Thermopane* with confidence. We have prepared folders on *Thermopane's* benefits in livestock raising. Mail the coupon for your copies.

SOLAR FARM BUILDING PLANS —The Better Farm Buildings Association has prepared complete plans. Working drawings, plus a complete list of materials, are available from L·O·F at $2 per plan.

L·O·F GLASS PLASKON FIBRE-GLASS

Thermopane
INSULATING GLASS



Libbey·Owens·Ford Glass Company
1893 Nicholas Bldg., Toledo 3, Ohio

Please send me:

☐ Free folders on *Thermopane* for dairy, hogs and sheep, poultry.

Plans for:

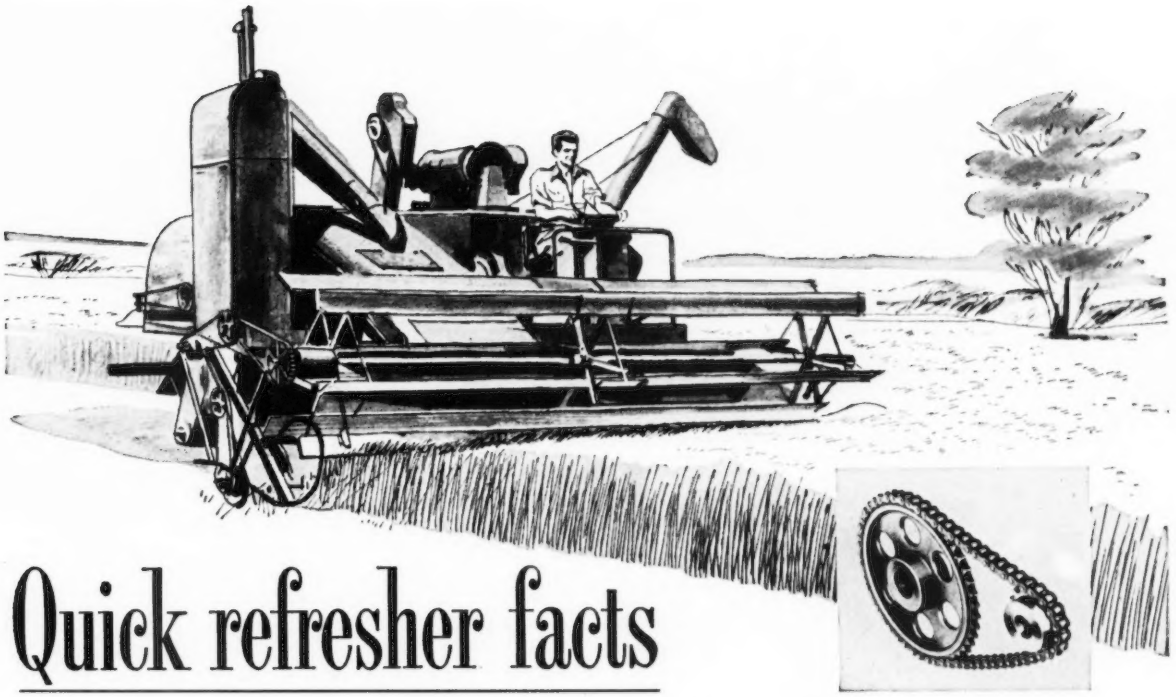
☐ Dairy barn ☐ Hog house
☐ Milkhouse ☐ Poultry laying house
☐ Calf barn ☐ Broiler house

For which I enclose $2 each.

Name_____

Street or R. R. No._____

Town_____ State_____



Quick refresher facts

ABOUT MORSE ROLLER CHAINS

You gain design flexibility, hold power-transmission component costs to a minimum, add new operating stamina to your products when Morse Roller Chains and Sprockets are at work for you.

DESIGN, ECONOMY FACTORS

Morse Roller Chains transmit power positively with less than 1% friction loss. They operate with maximum efficiency on long or short centers, mesh with sprockets on either side of chain to drive multiple-sprocket hookup.

Morse Roller Chains bring about major production economies in your plant. They run efficiently and well despite shaft end play, unparallel shafts. They permit increased drive center-distance tolerances. And because of Morse precision mass production methods, the complete drives come to you produced under the most economical conditions competitively priced.

STAMINA FACTORS

Morse Roller Chains will help you build even greater stamina into your machines, help you reduce downtime and maintenance problems for your customers. Here are a few reasons why:

1. PINS. Heat-treated special high-nickel, fine-grain alloy steel pins have hard case for wear resistance, tough inner core for high strength. Finish ground to close limits.

2. PIN LINKS. In Morse Roller Chains, heavy press fit holds pins immobile in pin link plates. Accuracy of assembly and close finish tolerance of pin and plate components assures proper clearances between pins and bushings for penetration by lubricant.

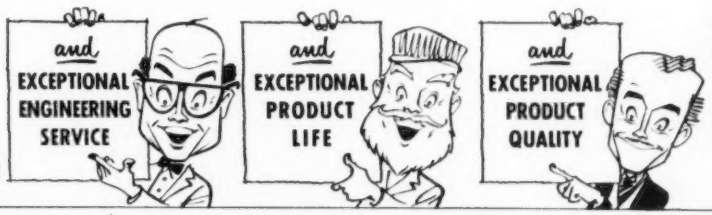
3. BUSHINGS. Morse bushings are case hardened and curled for maximum wear. Smooth inner bearing surfaces and true roundness help eliminate pin scoring, increase joint life, reduce elongation.

4. ROLLERS. Rollers are shot-peened for maximum wear and resistance to shock. Rollers are processed from special alloy steel. Close-tolerance surfaces provide even load distribution.

5. LINK PLATES. Morse link plates are specially treated to obtain maximum structural strength and endurance qualities necessary in highly stressed tension parts. Holes are accurately pierced and sized.

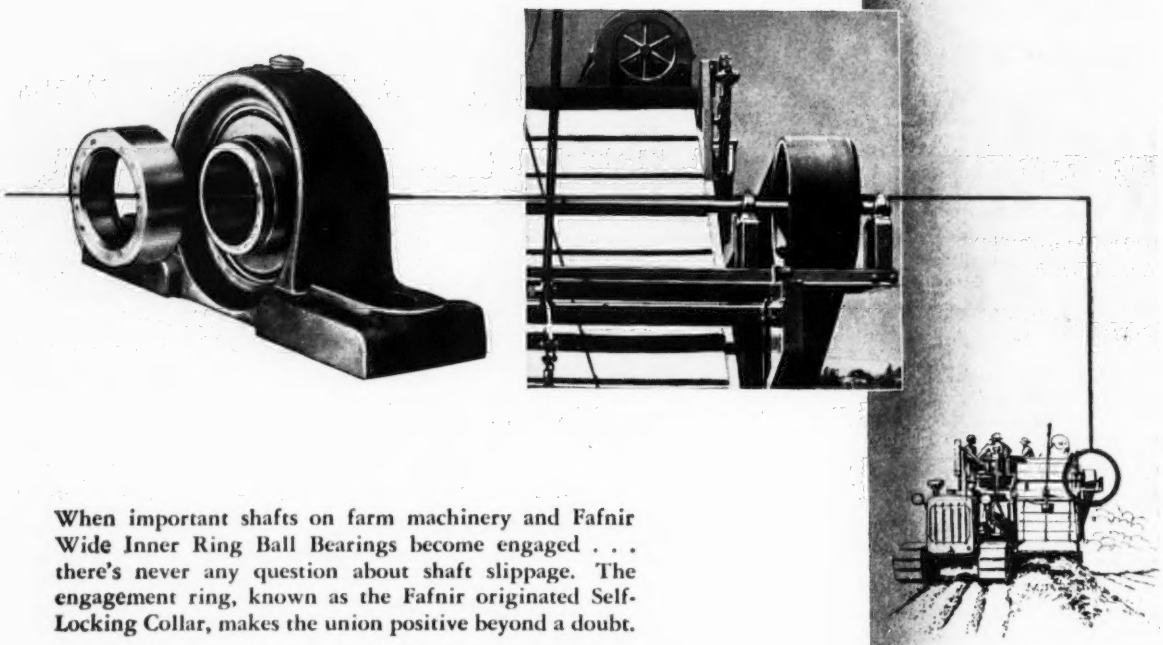
Morse Roller Chains, with corresponding sprockets in Types A, B, and C available from $\frac{3}{8}$" pitch to $2\frac{1}{2}$" pitch. Write for Catalog C51-50, or for details on any application you have in mind. MORSE CHAIN COMPANY • Dept. 519 • 7601 Central Avenue • Detroit 10, Michigan.

M=PT
MORSE *means* POWER TRANSMISSION



MORSE
MECHANICAL *POWER TRANSMISSION* PRODUCTS

The Engagement Ring makes it positive



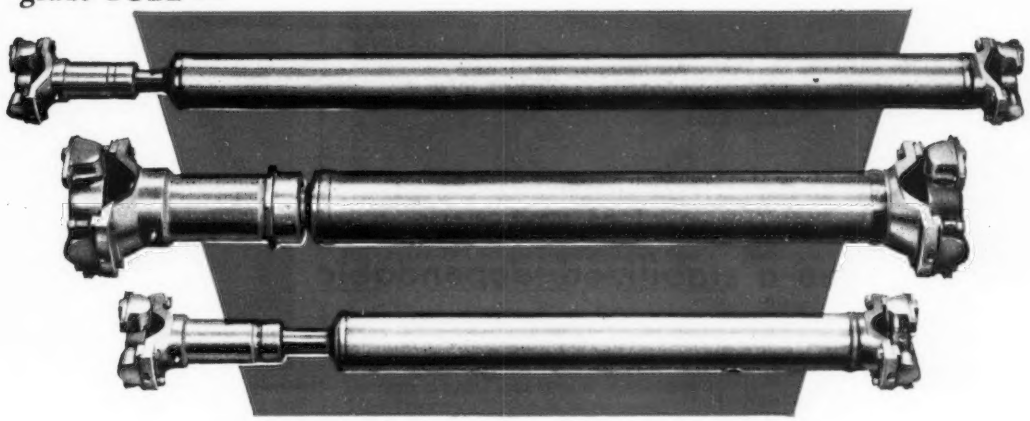
When important shafts on farm machinery and Fafnir Wide Inner Ring Ball Bearings become engaged . . . there's never any question about shaft slippage. The engagement ring, known as the Fafnir originated Self-Locking Collar, makes the union positive beyond a doubt.

In the design of the Self-Locking Collar, you'll find the reason for this positive action. The collar is machined as a mating eccentric cam to the wide inner ring of the bearing . . . and it is counterbored too. A quarter turn of the collar on the inner ring assures positive locking action between bearing and shaft. No set screw, lock nuts or adapters are needed. No adjustments of any kind are necessary and the bearing cannot be cramped or overloaded in mounting.

For straight shaft mounting, the Fafnir Wide Inner Ring Ball Bearing with Self-Locking Collar continues to rate "tops" as a feature of power transmission units. Its positive-engagement, *plus* simplicity-of-mounting, *plus* efficient seals are features that lead to savings in design, assembly and maintenance. Are you taking advantage of them? The Fafnir Bearing Company, New Britain, Conn.

LARGE SIZE JOINTS + LONG PROPELLER SHAFT = LESS TRUCK WEIGHT

If your truck must have large size universal joints — with a long propeller shaft—and operate at high speeds—it will pay you to specify MECHANICS "C" Type UNIVERSAL JOINTS with a 4″ or 4½″ diameter PROPELLER grade TUBE —



This combination provides strong, smooth running drive lines — with a substantial reduction in weight. Let MECHANICS engineers help develop a stronger, lighter, smoother running drive line for *your* truck, or other heavy duty equipment.

MECHANICS UNIVERSAL JOINT DIVISION

Borg-Warner • 2046 Harrison Avenue, Rockford, Illinois

MECHANICS

Roller Bearing BW

UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

6

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in six separate locations

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Ask for G-E Motors and Control on all Electrified Farm Equipment you buy!

GENERAL ELECTRIC FarmNews

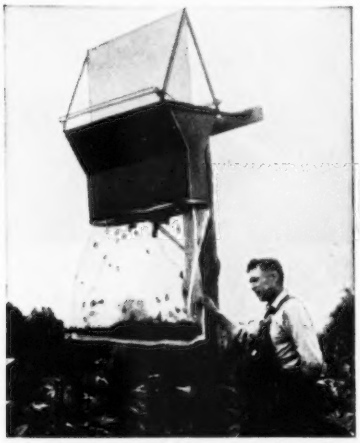
1878 75 1953 YEARS OF ELECTRICAL PROGRESS

MORE POWER TO THE AMERICAN FARMER through more electricity on the farm

AUTOMATIC POULTRY FEEDER SAVES WORK

"BLACK LIGHT" MOTH TRAP SAVES TOBACCO FROM WORM DAMAGE

Reduces or eliminates picking and spraying; increases tobacco yield



Pete Woody examining one of his tobacco moth traps. Moths end up in plastic bag and may be destroyed or used as chicken feed.

Tobacco grower Pete Woody, Rocky Mountain, Va., no longer has to pick horn worms from his tobacco plants. Nor does he have to dust or spray his fields. Mr. Woody has installed three "black light" traps to catch tobacco moths before they can lay their eggs. These traps do their work simply and inexpensively.

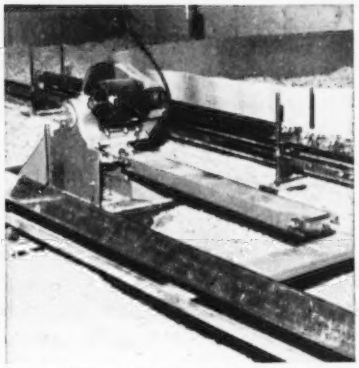
A G-E long-lasting black light shines against a fluorescent panel. Moths see the lighted panel and fly against it. After bouncing off the panel, the moths fall through a baffle and into a plastic bag. Then their egg laying days are over.

Mr. Woody says: "I think these traps are mighty fine. They really reduce horn worm damage to my tobacco. I'd recommend the use of black light traps to other tobacco growers."

Traps operate in wet weather and are not a hazard to humans or animals. Traps are equipped with G-E ballasts and starters. Check "Moth Traps" in the coupon to get the complete story.

Wisconsin farmer gets higher feed conversion . . . heavier chickens without supplementary feeding

Henry Stacey at hopper which dispenses up to 500 pounds of feed per hour. Accurate float meter keeps feed at desired level in trough.



Feeder drive unit is powered by a G-E motor. Nothing moves through the troughs but feed. Feeder is simple, compact, easy to install.

By using a "shaker type" mechanical poultry feeder, Mr. Henry D. Stacey, Ft. Atkinson, Wis. is able to save labor and raise bigger birds with less feed.

Mr. Stacey commented: "I've just finished raising a batch of chicks using my automatic feeder and I am very happy with its performance. My birds get all the feed they need, when they need it and there's no supplementary hand-feeding necessary. I get a feed conversion of 2.61 and that's very good. When I marketed my broilers at eleven weeks, the heavier birds weighed five pounds apiece."

Mr. Stacey's feeder is quiet and simple in operation. The feed moves evenly along the troughs in its original form. It is not powdered, shredded, or churned.

One important feature of Mr. Stacey's feeder is the feed control which turns the feeder on and off to meet the birds' demands. This is accomplished with a control pan at the end of the trough which stops the feeder when it is filled, and starts it again as soon as the birds eat up what is in the pan. This saves electricity, labor, and insures that the birds will always have enough fresh feed.

The feeder drive unit is powered with a G-E fractional horsepower motor. Use the coupon below to get the complete story on this flexible, labor saving farm machine.

MODERN WATER SYSTEM MEANS COMFORTABLE LIVING FOR 46 PEOPLE, PROVIDES BETTER FIRE PROTECTION, SUPPLIES WATER FOR ANIMALS

The Ashland (Ohio) County Farm and Home recently installed a new water system that supplies all the water for a variety of chores.

There are 46 residents and 12 employees in the home. Laundry is done in the home twice a week. On the farm, there are 53 head of cattle, 60 hogs, and 450 chickens to be watered. In addition, the water system furnishes water to 6 three-inch fire lines to insure maximum safety in the home.

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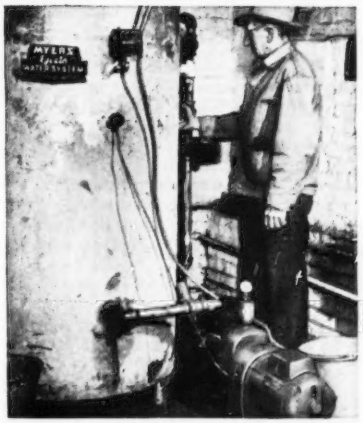

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AGRICULTURAL ENGINEERING

VOL. 34 SEPTEMBER, 1953 NO. 9

Engineering Design of a Livestock Physical Plant

C. F. Kelly, T. E. Bond, and N. R. Ittner
MEMBER ASAE MEMBER ASAE

EXTENSIVE use of mechanical equipment in agriculture has greatly lessened the number of man-hours of labor required for field crops. The gasoline engine and tractor have largely replaced man and horse power. It is not so easy, however, to mechanize the care of livestock, and as a consequence the peak-labor loads have been shifted to the ranch buildings and enterprises located there. Most of the field crops, produced with the aid of machinery, is used as animal feed to be fed by hand. It is estimated that 84 per cent of all field grains harvested and practically all of the hay eventually is stored, processed, and fed in or around the buildings (1)*. Eighty percent of the labor expended in the production of milk and eggs is centered in and around the buildings, 40 percent for hogs (2).

In the engineering design of a livestock enterprise, the agricultural engineer may approach the problem from the same viewpoint as that of a plant production engineer who designs a factory for the manufacturing of any commodity unit. In both cases the important thing is the efficient handling of materials. The flow of materials through the factory so that, by the shortest distance and at the right moment, power brings each portion to a point where it can be used, with the least expenditure of power and human labor, is the underlying philosophy of production engineering.

In addition, the agricultural engineer must take into consideration provisions for the optimum environment for animals, man, and stored products and feed; sanitation requirements and regulations; over-all appearance; safety of man, beast, and stored feed and products against fire and accident, and eliminating any nuisance value to the surrounding area due to odors, dust, and noise.

The flow of materials in a livestock enterprise can be considered as movement of animals, movement of feed, movement of water, movement of product (milk, eggs, etc.), movement of manure, and movement of man. The economy with which the flow of feed, product, livestock, manure, and water is accomplished will determine to a large extent how much labor is required, or, in other words, the movement of the man (Fig. 1).

Agricultural livestock enterprises differ from factories in that the material being handled is never in a steady state with regard to amount, size, and kind. What is done one day is seldom exactly repeated the next day. Cattle, swine, and poultry grow rapidly and require increasing amounts of feed and water. Their rations change through the feeding and growth period. They themselves take more room as they grow older. They require different environmental conditions for optimum growth as they increase in weight, and this change is not always parallel to the changes in the annual weather cycles.

In another respect livestock enterprises differ from factories. In the event of low prices or a satisfied market, the factory management may cut down production by operating fewer hours or shifts per day. On the other hand, the farmer must operate full time but on a smaller scale. One animal must be fed as many times per day as 1,000 animals. A drop in market price, change in estimated yield of his field crops, or an upset in the ratio of market price of animals to feed may require selling the animals sooner than planned, or holding them for a longer period. If the farmer cuts down on production, he may still want to retain his breeding stock. He may even want to go into a different kind of livestock enterprise, and his production plant should be amenable to change to fit the new problem with the least expenditure of time and money.

The plant can be analyzed and designed in the following steps:

1 Determine the problem
2 Construct flow charts for the materials
3 Make preliminary arrangement of plant
4 Select equipment and machinery
5 Evaluate preliminary design
6 Make final selection of equipment and plant arrangement
7 Design buildings to provide the correct environment for stored products, animals, machinery, and man.

These steps, with the exception of the last, will be discussed in order

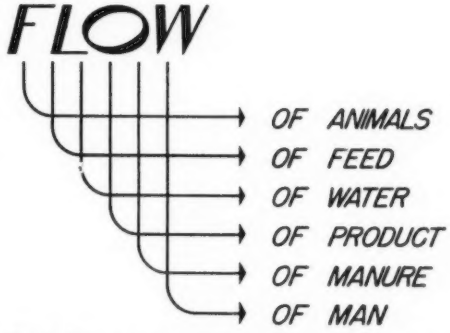

Fig. 1 The buildings and equipment of a livestock physical plant must be balanced for an efficient flow of the factors indicated

This paper was presented at a meeting of the Pacific Coast Section of the American Society of Agricultural Engineers, at San Luis Obispo, Calif., February, 1953.

The authors—C. F. KELLY, T. E. BOND, and N. R. ITTNER—are, respectively, associate agricultural engineer, California Agricultural Experiment Station (Davis); agricultural engineer (BPISAE), U.S. Department of Agriculture (Davis, Calif.), and associate specialist in animal husbandry, Imperial Valley Field Station, California Agricultural Experiment Station (El Centro).

Authors' acknowledgment: Credit is due Roy Bainer and L. W. Neubauer, University of California (Davis), for assistance in the preparation of this paper, and to Thayer Cleaver, U.S. Department of Agriculture, Urbana, Ill., for his inspiration.

*Numbers in parentheses refer to the appended references.

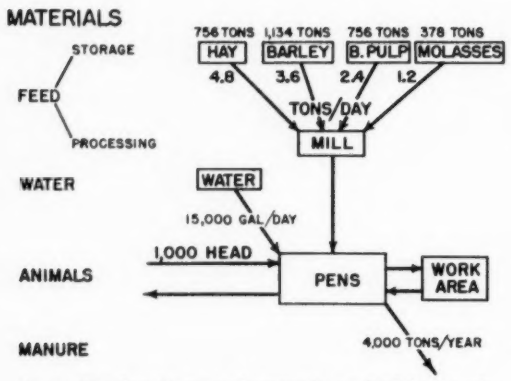

Fig. 2 The flow diagram of materials in a beef feedlot of 1000-head capacity

and explained briefly by the use of two examples, one a beef-feeding plant and the other a swine-production enterprise.

1 *Determining the Problem.* It is in determining the problem that the agricultural engineer must depend completely upon the farmer, the man who is going to operate the plant. Only the operator knows how many animals he plans to raise or feed, what materials he will be moving, and the many other problems that vary from man to man and are not given in textbooks and handbooks but depend upon the personal preference of the owner.

As the transient conditions vary with the months of the year, we suggest that the problem be determined chronologically, at one-month intervals, for one year. Data can be set up in tabular form, as shown in Tables 1 and 2. (These tables will be discussed at greater length later.) The first item of course should be the number of animals on hand at any particular time, together with their weight or stage of growth. The rations to be fed are determined by the producer. The total amounts to be processed and moved per day and the amounts to be stored per year and per month can then be calculated. The complexity of the tables will vary with the type of livestock and with the number of times per year the rations will be changed. For instance, the amount of livestock on hand in an egg- or milk-production enterprise would vary greatly where replacements are raised on the farm. Furthermore, the ingredients in the ration may vary from time to time as feed prices fluctuate or when certain feeds become unavailable.

2 *Flow Charts for Materials.* Setting up flow charts for the materials is the second step in the approach to a workable design. This will make it easier for the engineer to comprehend the problem and to see the possibilities in designing an efficient layout. The flow diagrams will bring together the amounts, distances, and times involved in the movement of the various materials. Boelter (3) has stated, "The operation of a fully automatic production line requires the temporal and spatial conjunction of events beginning with the materials and ending with the finished product."

The flow diagram will give an opportunity to ask, "Why should this process or job be included in the layout?" It will help to separate the various lines of flow in the preliminary plant layout, the next step in the design. The flow diagram should also include the data available regarding the type of management and the type of housing and handling of the animals that is desired by the producer. Diagrams showing lines of flow for a beef-feeding problem and for a swine-production layout are shown in Figs. 2 and 3, respectively.

3 *Preliminary Arrangement of Plant.* The preliminary arrangement of the plant cannot be considered entirely separately from the selection of equipment and machinery. In factories for the production of a commodity item, in fact, the entire plant may be designed around a new automatic machine that has become available. In an agricultural enterprise, at this stage the topographical features should be studied with regard to water and air drainage, the wind direction with respect to the dwellings should be considered, and the relation of the completed plant to available roads must be decided. These factors are probably more closely related to plant layout than is equipment. But, as stated before, equipment must be kept in mind at this stage.

The plant layout should now be drawn on paper, at first in rough sketches, and then to scale. A topographic map of the area should be the basis for all building and pen arrangements so that drainage can be given the close attention it deserves. Muddy lots can mean the loss of many dollars. If the plant involves the location of buildings, pens, self-feeders, etc., with respect to each other, it may be well to use templets, cutouts, or models for trying different arrangements. The use of machine models at a scale of ¼ in to 1 ft has become almost standard in industry. This scale may be somewhat too large for agricultural enterprises.

The preliminary layout should enable materials to flow with the least possible investment in equipment. Lines of flow must not interfere with each other. The scale drawing will enable distances to be accurately measured before construction starts and will allow time for various operations to be estimated. The available labor should be used to its fullest extent in controlling cheap power. It is not so im-

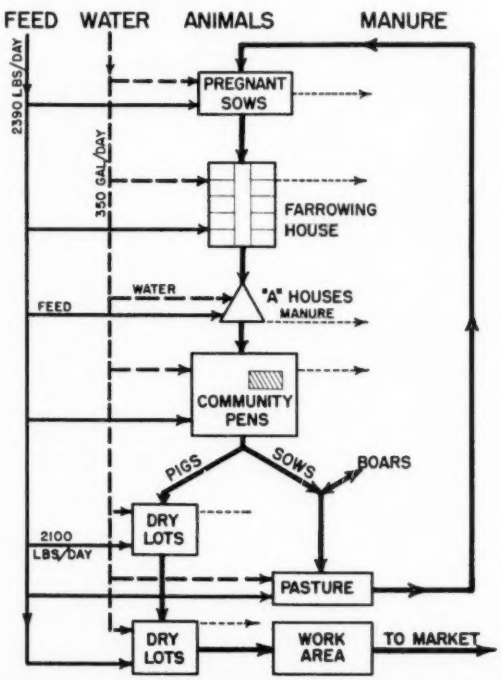

Fig. 3 The flow diagram of materials in a 40-sow hog-production enterprise

portant how far or how little a man moves as how much material moves when he moves. On the other hand, care must be taken not to overinvest in power equipment.

4 *Selection of Equipment.* The three components of a problem in materials handling are distance, time, and volume. We have indicated how a preliminary estimate of distances and volumes can be obtained. The time factor will depend both upon the labor available and how often a particular job must be performed. For instance, can the animals be fed only once a day, or must they be fed twice a day? Or should fresh feed be kept before them at all times? Must the manure be removed daily, annually, or at some other time interval?

Table 1. Animal-flow diagram, monthly weights, and total feed consumption for beef-feeding plant

Month	Animal flow	No. of animals	Average weight (lbs.)	Feed (lbs. per animal per day)	Total amount feed (tons/day) Hay	Rolled barley	Dried beet pulp	Molasses	Total amount water (gal per day)
January		1000	600	18	3.6	2.7	1.8	0.9	10,000
February		"	690	20	4.0	3.0	2.0	1.0	10,000
March		"	750	22	4.4	3.3	2.2	1.1	10,000
April		"	850	24	4.8	3.6	2.4	1.2	10,000
May		"	600	18	3.6	2.7	1.8	0.9	15,000
June		"	690	20	4.0	3.0	2.0	1.0	15,000
July		"	750	22	4.4	3.3	2.2	1.1	15,000
August		"	850	24	4.8	3.6	2.4	1.2	15,000
September		"	600	18	3.6	2.7	1.8	0.9	15,000
October		"	690	20	4.0	3.0	2.0	1.0	12,000
November		"	750	22	4.4	3.3	2.2	1.1	10,000
December		"	850	24	4.8	3.6	2.4	1.2	10,000
		Annual Total[1]			1,512	1,134	756	378	

[1] Based upon months of 30 days each.

Equipment should be selected that will make the best possible use of the labor available. If for the sake of safety, it is necessary to have two men on the job for part of the day, for such things as handling cattle in corrals, operating two machines at the same time, etc., there seems little point in mechanizing to such a degree that there will not be enough work to keep them busy all the time.

Catalogs and price lists of manufacturers of equipment must be available for this design step. Catalogs of companies serving other manufacturing and processing industries should be included as well as those of the usual manufacturers of farm equipment. An attempt should be made to set up comparative costs of purchasing, erecting, and operating equipment of different types. This might involve a comparison of auger, belt, chain, or pneumatic conveyors, monorails, trucks, and horse- or man-powered trailers or carts, for a particular job of materials moving. There is no common denominator for getting the proper combination of equipment.

The commercial equipment available for the conveyance and handling of materials in and around farm buildings is meager. In many cases portable elevators (bought because locally available) are practically constructed into a building and never used otherwise, the value of the rubber tires, frame, etc., being completely lost. A visit to any agricultural area specializing in livestock will reveal examples of homemade materials-handling equipment that the farmers and ranchers have designed to fit their particular problem. These are, for the most part, based upon elements from discarded combines, threshers, etc. While it may be fortunate that these machines can be made use of after their normal service in field work, it is unfortunate that the farmer must spend time and money adapting them to his buildings. The agricultural engineer must develop requirements for farm structures so that the manufacturers of equipment can provide a line of materials-handling machinery of various types, at prices that can be afforded, and have the assurance that there is a market available.

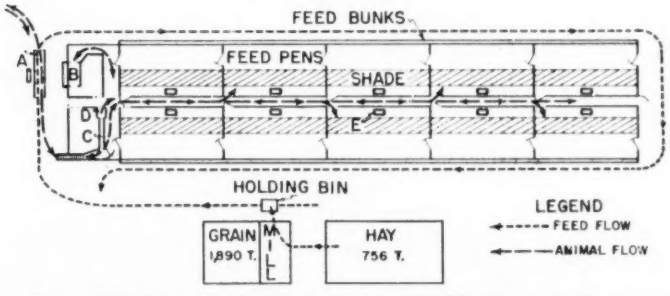

Fig. 4 Preliminary plant layout of a 1000-head beef feedlot: A, truck scale; B, corral scale; C, chute; D, squeeze; E, drinkers

In the final analysis, the proper equipment will be that which provides the greatest margin of profit for the producer, after labor, operating, and depreciation charges have been allowed. Carter (4) states, "It is unfortunate . . . that building improvements are classed as a part of farm real estate instead of as operating equipment." This philosophy should be kept in mind when selecting the equipment.

5 *Evaluating the Design.* The physical plant in its first form having been designed and placed on paper, it can now be analyzed in the whole. The engineer, in conference with the farmer-producer, should determine carefully the answers to the following questions:

(a) How much money will be invested in equipment?

(b) How many hours will each piece of equipment operate daily and annually?

(c) Is there cheaper equipment available that would do the same job in only slightly longer time?

(d) Can some of the jobs be eliminated without undue harm to livestock production or gains?

(e) Are the yards, pens, etc., laid out so as to require the least amount of paving of roads and feed platforms?

(f) What is the probable life of the plant and equipment? Will all parts depreciate at about the same rate, and if not, will repairs be available at a reasonable cost?

(g) Will the plant work as well in winter as in summer, or will large amounts of shelter be necessary to protect the equipment, livestock, and feed from inclement weather?

(h) What are the possibilities in this design for expansion or contraction, or for changing to another type of livestock enterprise?

(i) Is the plant being designed around a method or machine which may be obsolete in a few years?

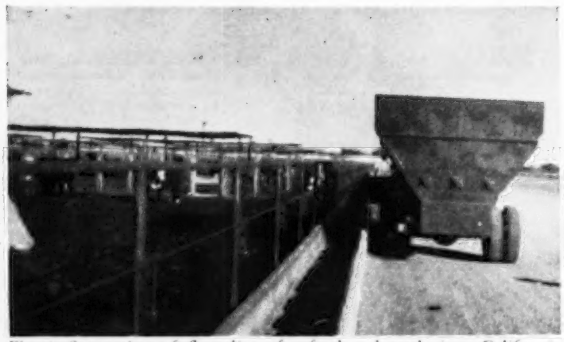

Fig. 5 Separation of flow lines for feed and cattle in a California beef feedlot

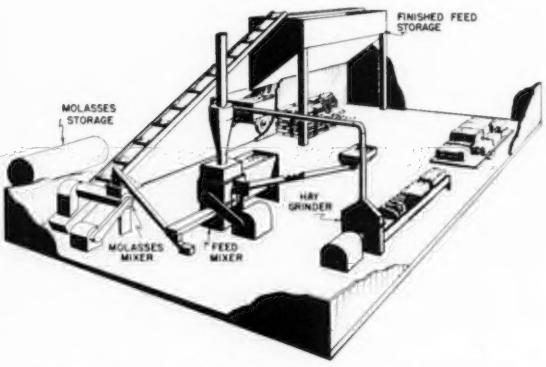

Fig. 6 Proposed layout of a feed mill for a 1000-head beef feeding plant

The answers to these and many other questions will suggest changes that can be made in the design to increase its efficiency, or decrease the cost with little effect on the efficiency. The producer may find that, by simply adding a few pens or making other similar small changes, he can increase the number of animals cared for without materially increasing the investment. Perhaps by decreasing the size of his enterprise slightly he can lower considerably the initial investment, or do away with the services of some hired labor, so that his net returns will be greater.

6 *Final Selection of Equipment and Plant Arrangement.* This might also be called the "redesign" step. It involves making use of the data just determined in step 5. Greater thought should be given to the sanitation and environmental features of the layout and to the actual buildings themselves. The plan may be redrawn several times before what is considered the optimum layout is obtained. It is much cheaper to make the less desirable plans on the drawing board and actually construct only the best plan. Numerous examples of the value of this approach to factory design are given by Immer (5) and Mallick and Gaudreau (6).

Two examples of the design of livestock physical plants of differing types will now be briefly presented. The first is a beef-feeding plant where the number of animals stays constant but the amount of feed varies. The second is of a hog-production enterprise, where the number of animals changes from time to time. Both are assumed to be in California with a mild climate.

EXAMPLE OF A BEEF FEEDLOT

1 *The Problem.* A producer wishes a feedlot with a maximum capacity of 1,000 head. Cattle are to be purchased at about 600 lb and fed to 850 lb in approximately 120 days. The producer expects to operate the entire plant with the help of one hired man, each working a total of 8 hr per day. The same amount of labor will be available on weekends.

The ration will be alfalfa hay 20 percent, barley hay 20 percent, rolled barley 30 percent, dried beet pulp 20 percent, and molasses 10 percent. A mill to prepare the ration daily in a chopped and mixed form is to be part of the plant. The hay will be purchased in bales, weighing about 100 lb each, the rolled barley in 100-lb sacks, and the dried beet pulp in 50-lb sacks. The molasses, weighing 11.7 lb per gal, will be delivered in bulk. Storage must be provided for half the total annual consumption of hay and all of the barley and pulp, as the feeder wishes to be able to take advantage of buying in large quantities when the price is "right."

The approximate daily total amount of feed to be handled by the plant for any month is listed in Table 1. Since the barley hay and alfalfa hay are both in the same type of "package" when received (100-lb bales), they are not separated in the materials list. The amount fed per animal per day is based upon the figures of the National Research Council (7). The rate of gain is estimated at 2 lb per day per animal by the same reference. The problem is to proportion, mix, and deliver to 1,000 animals a total of as high as 12 tons of feed per day (made up of 4.8 tons of hay, 3.6 tons of barley, 2.4 tons of beet pulp, and 1.2 tons of molasses) and 15,000 gal of water per day.

Based on the operator's experience, he feels that at least 3 hr per day of both his and the helper's time will be needed for medical attention to the animals, cleaning the pen drink-

Table 2. Animal-flow diagram, monthly weights, and total feed consumption for hog enterprise of 40 sows, 2 boars, and 280 growing and fattening hogs

Month	Animal flow	Average weight, growing pigs (lbs.)	Feed 1/ Per animal (lbs./day) Sows	Boars	Growing	Total 2/ lbs./day	Tons/month	Water 3/ (Gals./day)
March	Farrow	With sows	12	5	-----	490	7.4	40
April		" "	12	5	-----	490	7.4	40
May	Wean	40	7	5	3	1130	17.0	230
June	Boar	100	7	5	5.3	1774	26.6	250
July		150	7	5	6.3	2194	32.9	275
August		200	7	5	7.5	2390	35.8	350
September	Farrow	With sows	12	5	-----	490	7.4	40
October		" "	12	5	-----	490	7.4	40
November	Wean	40	7	5	3.0	1130	17.0	230
December	Boar	100	7	5	5.3	1774	26.6	250
January		150	7	5	6.8	2194	32.9	275
February		200	7	5	7.5	2390	35.8	350

1/ From "Recommended Nutrient Allowances for Swine," National Research Council, Washington, D.C., 1944.

2/ Based on 30-day months.

3/ From Morrison, F.B. "Feeds and Feeding," The Morrison Publishing Co., Ithaca, N.Y. 1936.

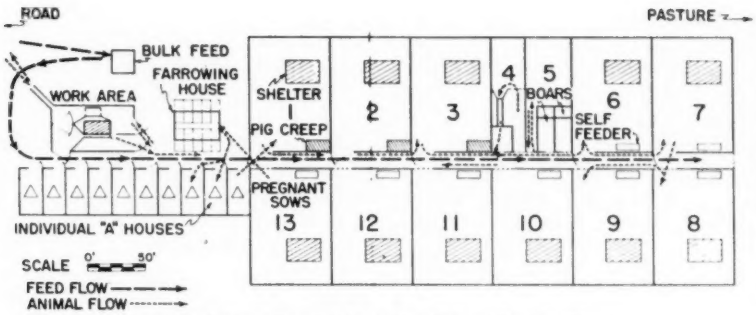

Fig. 7 Preliminary layout of a 40-sow hog-production plant

ers, repair to the corrals, etc. This leaves 5 hr per day of two men's time for processing and distributing the feed to the animals.

2 *Flow Chart for Materials.* The feed is taken through the steps from storage to feed pens in the required rates of flow, or tons per day, in Fig. 2. The storage requirements are shown. Water is treated in the same way, assuming that storage should be provided for three days' supply (45,000 gal). The animals must be able to be moved into and out of the feeding pens quickly and safely, and have an easily accessible work corral or area. Because the animals' increase in weight is the "animal product," flow lines for this can be neglected. The manure must be removed in the amounts given (based upon 4 tons per animal per year) (8), but the flow diagram does not tell how or when this is to be accomplished.

3 *Preliminary layout.* A preliminary layout is shown in Fig. 4. The construction falls naturally into three parts: *(a)* the cattle pens, *(b)* the mill, and *(c)* the storage.

The basic measurements for the cattle pens are as follows, for the climatic area being considered: pen area, about 200 sq ft per animal in summer; shade area, 60 sq ft per animal, and feed bunk, 2 ft per animal (9).

A decision must be made at this point as to whether a conveyor-type feed bunk or a self-unloading truck or trailer or a hand-unloaded truck or trailer is to be used for distributing the feed to the animals. In the first case, the animals will feed from both sides of the bunk, in the second and third cases from one side only. (As stated before, the preliminary layout cannot be entirely separated from the next step, the selection of equipment.) The decision will be based on the initial costs, time for feeding, upkeep costs, power requirements, personal preference of the operator, etc. In the case of our example, we find that the maximum length of conveyor bunk commercially available in California is 600 ft, which would feed about 600 cattle — 400 less than the desired number. Preliminary investigation indicates that the cost of two of these bunks would be slightly more than one self-unloading truck, and it is decided to make the preliminary plan on the basis of the truck. Then 2,000 ft of bunk will be needed, to be fed from one side. As shown in Fig. 4, the area is divided into ten pens of 100 animals each, with 200 ft of feed bunk each. The pens will be 100 ft deep (200 sq ft per animal), and the shades the full length of the pens and 30 ft wide (60 sq ft per animal). The work alley connecting the feed pens to the work corral is shown between two rows of pens, and the feed bunks on the outside of the pens. This arrangement separates very well the flow lines of feed and animals. A view of the relative arrangement of pens, alley, and feed bunk is shown in Fig. 5. The work corral, with scales, unloading dock, squeeze chute, and isolation pens, is available to the paved road for delivery to and from the feed pens. A truck scale is provided for weighing loads of cattle and for trucks of feed from the mill.

The path of animals and feed truck is indicated by the arrows. The waterers are on the opposite side of the pens from the feed bunks, tending to spread out the manure over a larger area and facilitate drying, since it will be moved only once a year by a commercial hauler.

The mill of course should be located within a reasonable distance of the pens, to cut movement to a minimum, and the bulk-storage buildings close by for the same reason. Fire regulations and requirements must be considered here.

4 *Selection of Equipment.* The feed mill is the heart of the beef-feeding plant, and the point where the greatest use can be made of power machinery to replace human labor.

About one hour's time for the two men will be required for distributing the mixed feed to the feed bunks by a self-unloading truck. This is based upon feeding twice each day, a truck speed of 3 mph, and a maximum of 12 tons of mixed feed. Allowance is made for returning empty to the mill, filling the truck from an overhead bin, dead time in high gear across ends of pens, etc. There will be left at least 4 hr of two men's time for processing the feed.

Referring to Table 1 again, it is found that the maximum amount of feed on any day will be 4.8 tons of hay, 3.6 tons of rolled barley, 2.4 tons of dried beet pulp, and 1.2 tons of molasses. Translated into terms of "packages," there will be 48 bales of alfalfa hay, 48 bales of barley hay, 72 sacks of rolled barley (100 lb each), 96 sacks of dried beet pulp (50 lb each) and 205 gal of molasses. The number of packages per hour, for three different rates of processing the feed, are shown in the following tabulation:

	Packages to be handled per hour				
Elapsed time (hr)	Hay (bales)	Rolled barley (sacks)	Beet pulp (sacks)	Molasses (gal)	Rate of processing feed (tons per hour)
1	96	72	96	205	12
2	48	36	48	103	6
3	32	24	32	68	4

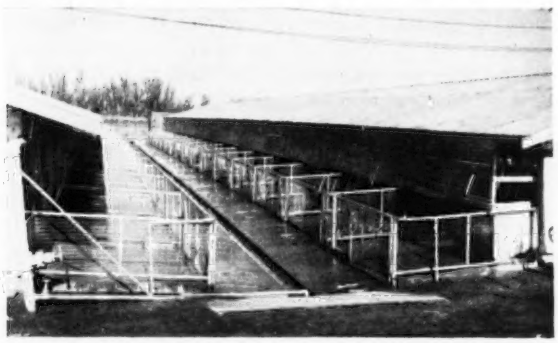

Fig. 8 Central farrowing houses using water for transporting manure to an irrigation canal in a large California swine-production enterprise

Since the rolled barley, beet pulp, and molasses are already in a form suitable for the cattle, the only processing necessary for them is mixing together in the proper proportions with the hay. The hay must be ground to facilitate mixing and to put it in a more fluid form for distribution to the feed bunks.

Study of the above data indicates that the following equipment will be necessary in the mill:

1 Hay grinder, with blower
2 Hay drag (for feeding grinder)
3 Mixer for hay, grain, and beet pulp
4 Metering device for grain and beet pulp
5 Molasses pump and meter
6 Mixer for molasses and hay, grain, and beet pulp
7 Overhead holding bin for delivery to truck
8 Elevators and conveyors to move ingredients between grinder, mixer, and overhead bin.

What should be the capacity of these pieces of equipment? The services of two men for 4 hr are available. Normally it would appear that one man should feed the hay grinder and the other look after the sacked grain. If the job is done in 2 hr, the sack man must empty 84 sacks per hour, while the hay man is laying 48 bales on the hay drag and removing the ties (see tabulation on page 603). Although this would be relatively easy for the man on the hay, the man on the sacks might be overworked. If 3 hr are used, the sack man will empty only 54 sacks an hour, while the hay man is laying 32 bales (alternately alfalfa and barley) on the drag. The capacity of the hay grinder then must be 32 bales per hour, and of the dry mixer 3.6 tons per hour. The secondary or molasses mixer and most of the conveyors must handle about 4 tons per hour. The use of equipment of these capacities will leave one hour per day for assembling the bales and sacks and greasing the machines.

A proposed layout for the mill is shown in Fig. 6. The hay drag is set for 32 bales per hour, and the bales must be placed to touch each other. The ground hay is blown directly to the mixer, where it meets the barley and beet pulp, which have been dumped into the floor hopper. The auger acts as a partial mixer and also, in conjunction with a metering roll in the mixer, proportions the concentrate to the hay. The dry mix then moves to the molasses mixer where it meets the molasses, pumped at the correct rate from the bulk storage. The completed feed is elevated to an overhead bin for final delivery to truck or trailer by gravity.

5 *Evaluate Preliminary Design.* Study of Figs. 4 and 6 reveals the following points that should be reconsidered:

(a) It will be necessary to pave the driveway for the self-unloading truck in front of the feed bunks and across the ends of the pens. The amount of paving could be more than cut in half by placing the bunks along each side of the work alley and relocating the mill near one end of the alley. Unpaved alleys for the animals could be constructed on the outside of the pens, or the pens could be lengthened about 16 ft to allow for a gate from each pen into the central alley. This would still allow 200 ft of feeding space for each pen. However, then the operator of the truck would have to stop and start the unloading mechanism after each 200-ft length of manger.

(b) Further study should be given the location of the mill with reference to the lots and highway, keeping in mind the capacity of the feed truck, where it will be when it becomes empty, and how far back the dead run to the mill will be.

(c) The feed truck will be used less than an hour each day. Consideration should be given the use of a lower-cost truck or trailer without the self-unloading feature. Two men for unloading by shovel would then be needed, requiring an extra man for about one hour each day.

(d) Two scales are shown. If the truck scale is located adjacent to the work corral, with suitable wing gates, it can also be used for unloaded animals.

(e) The disadvantage of handling the concentrates in sacks rather than in bulk is apparent. The producer should be advised that all manual handling of concentrates would be eliminated if bulk buying were possible. Bulk storage would be necessary for both whole and ground grain. The hay grinder could also be used for processing the whole barley. A larger grinder, available at only slightly greater cost, could then be used, lowering the mill-operation time and releasing labor for distributing feed in the mangers with much lower cost equipment. This change would also allow the enterprise to expand later, if desired, by only increasing the number of feed pens.

6 *Redesign of Plant.* The plant should be redrawn, incorporating the changes believed advantageous as determined in step 5. This plan should then be studied with the producer and searched for further changes that might improve efficiency and sanitation, or lower its cost.

EXAMPLE OF A SWINE-PRODUCTION ENTERPRISE

1 *The Problem.* A swine enterprise differs from a beef feed lot in that breeding stock is maintained, and the number of animals may vary during the year. In this example the producer desires a breeding herd of 40 sows and 2 boars and will sell the offspring as fat animals at about 200 lb weight. They are to be fed and fattened in dry lots, with self-feeders. Pasture will be available for the dry sows and boars. All feed is to be purchased ready mixed, in bulk, delivered once each month. Sows are to farrow in March and September. It is planned that the fat animals will be marketed just prior to these dates. The problem for the engineer is outlined in Table 2, the daily and monthly feed requirements being determined parallel to the animal-production diagram. The number of fattening animals is based on weaning seven pig litters. Growth rate and feed consumption are from the data of the National Research Council (10).

It will be necessary to distribute as high as 2,390 lb of feed per day, and to store as much as 36 tons at one time. The minimum amount of water, for drinking purposes, will be about 350 gal per day.

The reader's attention is directed to a discussion of feeding garbage to hogs, utilizing the straight-line production system, by Sullivan, Maharg, and Hughes (11).

2 *Flow Chart for Materials.* The movement of the animals may be considered first. In this case we have a product —the young pigs—that cannot be separated from the other animals as far as housing and equipment are concerned, as would be the case with milk, eggs, etc., and so here they will be thought of as part of the animal flow line.

The producer indicates he would prefer to use a central farrowing house, bring the sows in a day or so before farrowing, leave them in the central house 5 to 10 days after farrowing, remove sow and litter to individual A houses for a week, and then put six sows and their litters together in a community dry lot until weaning at 8 weeks. The sows would then be put on pasture and the pigs grown out on dry lot, self-fed. These factors have been taken into consideration so far as possible in the flow diagram of Fig. 3.

3 *Preliminary Plant Layout.* The movement of the animals is relatively more complex and movement of feed more simple than in a beef feedlot. Expanding the ideas of the flow chart, a preliminary layout is shown in Fig. 7. The pregnant sows are brought to pen 13 a few days before farrowing so that they can be watched closely. They can be moved easily the short distance to the farrowing house, and after farrowing to the A-house lots with their pigs. Pens 1, 2, and 3 are provided with creeps for the pigs for the period when six sows and litters are held in community pens. After weaning, the sows are driven down the alley to pasture, and the pigs to pen 6. At intervals the pigs can be sorted and moved along to pens 7, 8, 9, 10, 11, and 12. They should reach pen 12 at about the time they are ready for market. A truck-loading ramp is provided at the work area. The work area also has a scale, chute with sorting gate, and shaded area for giving medical attention. Four small holding pens are included here. A dipping vat is shown in pen 4. Pen 5 is for the breeding crates.

Feed is delivered in bulk (ground and mixed) to an overhead bin by a feed dealer. It can then be conveyed by truck or trailer to the self-feeders in the creeps and feeding pens and to troughs in the A-house pens, via the work alley.

4 *Selection of Equipment.* The mechanical equipment, aside from the self-feeders, waterers, etc., will be only that needed for moving feed from the bulk storage to the pens. If self-feeders large enough for a one-week supply are placed in each pen, 7 or 8 tons will be moved one day per week to the fattening pens, and a small amount daily to the A houses and farrowing house at certain times of the year. A truck or trailer drawn by a small tractor, with an unloading auger for filling the self-feeders across the fences from the alley would appear desirable. The same small tractor can be used for the daily feeding of the A houses.

5 *Evaluation of Design.* Study of Fig. 7 shows that improvements are still possible. Consider the following points:

(a) The work area is unhandy for sorting, weighing, and vaccinating the pigs in the fattening pens. Thought should be given to moving the work area near pens 4 and 5.

(b) Fences between the pens should have gates arranged so that truck or tractor can be driven down through pens without using work alley, for cleaning, moving shelters, self-feeders, etc.

(c) No attention is given to drainage of pens and to gutters on farrowing house floors and pens for wash-water disposal.

(d) There is no provision for the replacement breeding stock.

(e) Water for drinking, sanitation, and fire-protection purposes has been overlooked.

(f) This plant would be rather difficult to expand. There is little room available for extending the length of the farrowing house. The points stated under *(a)* above would become increasingly more objectionable as the number of pens was increased to the right of the plan.

6 *Redesign of Plant.* The plant outline of Fig. 7 should be redrawn, in an effort to rectify as many of the points considered above as possible.

CONCLUSION

Design of a livestock physical plant requires careful consideration of the fundamentals of handling of materials if the producer is to realize maximum efficiency of production and net return. The agricultural engineer is to the livestock farmer what the plant-production engineer is to the manufacturer. Thus the duty of the agricultural engineer is that of combining the buildings, equipment, and materials of a livestock enterprise into a smooth, efficiently balanced production plant that provides an economically harmonious flow of animals, feed, water, product, manure, and man.

In this paper a logical, step-by-step sequence is presented by which a livestock enterprise can be engineered as an efficient production plant. Two examples are given, one of a beef feedlot and the other a swine-production enterprise, to amplify the design procedure and to emphasize the importance of engineering.

The foregoing discussion is presented, not as a new "method" of designing farm structures, but to point out the fact that structures in our mechanized agriculture must pay their way by becoming part of the over-all mechanism itself. Equipment to replace labor must increase profit as well as production. Sanitation and environment are just as important as ever. In fact, as new feeds, medicines, and methods of production are discovered, sanitation and environment increase in importance for stored products, animals, and man.

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Determining the Dielectric Properties of Grain

S. O. Nelson, L. H. Soderholm, and F. D. Yung
ASSOC. MEMBER ASAE MEMBER ASAE MEMBER ASAE

SUMMARY

THE Boonton Q-Meter equipped with a newly designed coaxial cylindrical test-condenser has been used successfully in determining the dielectric properties of grain in the frequency range from 1 to 50 megacycles. The advantages of this method include (1) the reduction of inaccuracies due to residual and lead inductances through utilization of the reactance-variation method of measurement and (2) provision for measurement of the electrical properties of benzene or other standard liquids by which the accuracy of determinations may be checked. A detailed description of the test condenser and a brief explanation of the method are presented.

Formulas are given for the calculation of dielectric properties from electrical measurements. Tests using benzene as a standard material indicate that the method permits accurate measurements of the electrical properties in the frequency range from 1 to 50 megacycles. Values of dielectric constant, loss tangent, loss factor and conductivity in this frequency range are shown as obtained from a typical test made on a sample of barley.

INTRODUCTION

During the past two decades there has been increasing interest in radio-frequency or "dielectric" heating. Recent investigations concerning insect control, drying, and destruction of fungi and bacteria have indicated promise for practical applications in agriculture. For computations involving the behavior of materials in a radio-frequency field, a knowledge of properties such as dielectric constant and loss factor is essential. Recent experiments with grain have revealed a definite need for such information.

The dielectric properties of grain are affected by a number of variable factors including moisture content, density, temperature, and variety. These variables necessitate the determination of the dielectric properties of each sample of grain used in dielectric heating experiments. The method of measurement presented offers a practical solution to this problem.

Measurements of the electrical characteristics of materials utilizing the Boonton Q-Meter, type 160-A,* have been reported by Brown, Hoyler, and Bierwirth (1947). Similar procedures for the measurement of the electrical characteristics of grains have been used by Wratten (1950) and Kleis (1951). There is no verification of the reliability of these measurements in the reports.

The Boonton Q-Meter provides a convenient method for various radio-frequency measurements. This instrument was used by the authors with a simple coaxial test-condenser in determining the dielectric properties of wheat samples employing methods similar to those previously reported. The results obtained were inconsistent, particularly at frequencies above 20 megacycles. The doubtful accuracy of these determinations indicated the need for a method, suitable for use at higher frequencies, in which the accuracy of measurement could be checked by use of benzene or other materials of known dielectric properties.

METHODS AND EQUIPMENT

The method presented in this paper is an adaptation of the reactance-variation principle reported by Hartshorn and Ward (1936) and Wangsgard and Hazen (1946). The use of the Q-Meter for the reactance-variation method requires only the construction of a special sample-holding test-condenser and the winding of an appropriate set of coils (Fig. 1). A sectional drawing of the test-condenser is shown in Fig. 2 and a disassembled view of the parts is shown in Fig. 3.

The upper part of the inner electrode *(a)* was made of ¼-in brass tubing with a machined plug pressed into one end and threaded so that it could be screwed into the lower part of the inner electrode *(b)* which was made from a solid ¼-in brass rod. A piece of ¼-in polystyrene *(c)* was machined for a tight fit and holds the lower parts of the two electrodes in place. The outer electrode of the test-condenser *(d)* was also made in two parts from brass tubing of 3 in diameter. Brass rings *(e)* were silver soldered on the ends of the tubes and machined so that the two parts screwed together. A 1/16-in disk of glass-bonded mica insulation *(f)*, known commercially as Mycalex or Mycroy, was machined and ground to fit between the upper and lower sections of the condenser. Thin gaskets, about 0.020 in thick *(g)* were cut from Thiokol synthetic rubber and placed on top of the insulation disk to form a tight seal when the test-condenser was assembled. Notches were cut in the top of the upper part of the inner electrode so that a small rod could be inserted and the electrode screwed down snugly. Connections for the condenser were made by drilling and tapping the base of the lower section of the inner electrode for a banana plug *(h)*, and fastening another banana plug to the outer electrode with a brass strip. The assembled unit can be conveniently connected to the Q-Meter by simply plugging it into the external condenser terminals.

A small variable air condenser *(i)* was mounted in the lower portion of the test condenser, and equipped with a pointer knob and dial scale. The variable condenser with a range of about 16 $\mu\mu f$ was chosen especially for test samples having volumes of approximately 100 cc and dielectric constants from 1 to 10. For samples of larger volume or higher dielectric constant, a variable condenser with a greater range would be desirable. The rotor of the condenser was electrically connected to the brass mountings which were fastened to the lower section of the outer electrode with screws. A strip of brass shim stock *(j)* was tinned and soldered to the stator of the condenser in such a way that it made a satisfactory spring contact with the inner electrode. Both

This paper was prepared expressly for AGRICULTURAL ENGINEERING. It is a joint contribution from the department of agricultural engineering, Nebraska Agricultural Experiment Station, and the division of farm electrification (BPISAE) U.S. Department of Agriculture, and published with the approval of the Director of the Nebraska Agricultural Experiment Station as Journal Series Paper No. 609.

The authors — S. O. NELSON, L. H. SODERHOLM, and F. D. YUNG — are, respectively, graduate student, University of Nebraska; associate agricultural engineer, division of farm electrification (BPISAE), U.S. Department of Agriculture, and research engineer in rural electrification, University of Nebraska.

*Manufactured by Boonton Radio Corp., Boonton, N. J.

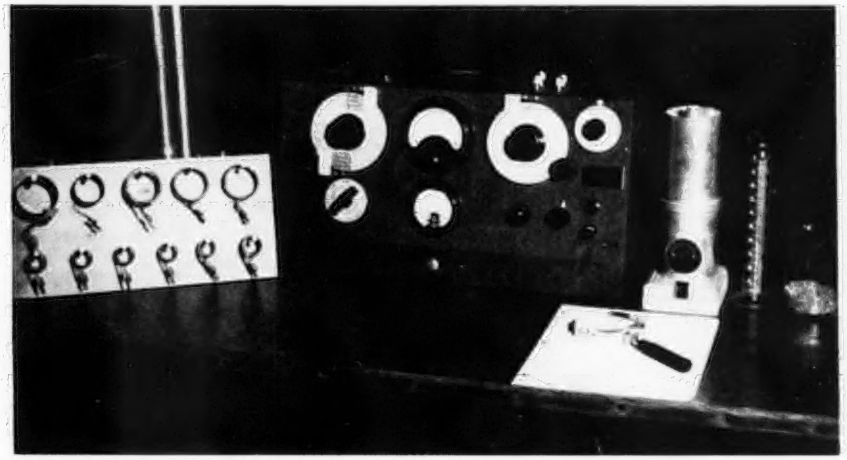

Fig. 1 The Q-Meter, test-condenser, coils and auxiliary equipment

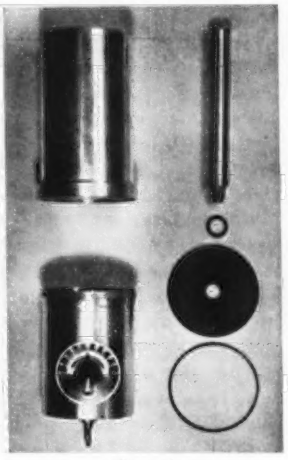

Fig. 3

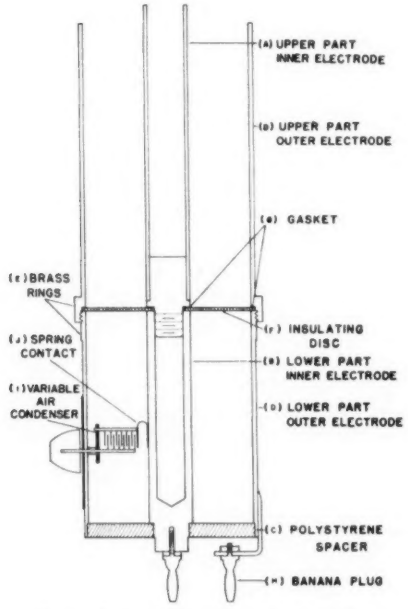

Fig. 2 Sectional drawing of test-condenser

electrodes of the test-condenser were silver plated before assembly.

The small variable condenser in the test cell was calibrated using the Q-Meter at frequencies of 0.4, 1, and 5 megacycles, where the effects of residual and lead inductances were not troublesome. The calibration was obtained by comparison with the scales of both the main and vernier tuning condensers independently. A large number of measurements distributed over the entire scale of each condenser was used to obtain a reliable average. Calibration is also possible using any suitable standard.

This test-condenser has several advantages when compared with other types which have been tried. The use of the glass-bonded mica insulation makes possible the measurements of the electrical characteristics of benzene or other standard liquids. The glass-bonded mica disk has favorable low-loss characteristics and may be made thin to keep the discontinuity of the electrode surfaces at a minimum. The small variable air condenser in the test-condenser assembly provides a circuit that can be retuned to resonance with little change in the geometrical configuration of the circuit components. The location of the variable condenser near the grain sample also reduces the effect of residual and lead inductances to a low value. The test condenser may be easily disassembled for cleaning or substitution of an insulation disk of a different material.

The Q-Meter utilizes a series resonant circuit. The characteristic curve of the potential across the capacitive component is similar to that shown in Fig. 4. The potential difference, V_m, is read on the Q-Meter voltmeter at reasonance, or, more specifically, when the potential across the condenser is maximum. The change in capacity, ΔC, is produced by changing the Q-Meter vernier condenser until the voltmeter registers a value, V, on both sides of resonance. ΔC is then recorded as the total variation of capacity as indicated by the settings, $\pm C$, of the vernier condenser.

Measurements of V_m, V, and ΔC, are made with the test-cell variable condenser set to zero with a known volume of grain in the cell. The main tuning condenser of the Q-Meter is adjusted for resonance as indicated by a maximum reading on the Q-Meter voltmeter and the reading of V_m recorded. The circuit is then detuned on one side of resonance by variation of the vernier condenser to obtain a voltmeter reading, V (the value of V being selected to give a ΔC of 1 $\mu\mu f$ or more). This value of V and the vernier condenser

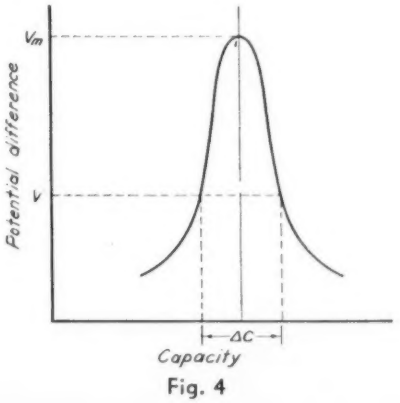

Fig. 4

reading, $+C$, on this side of resonance are noted. The circuit is then detuned on the other side of resonance by an amount sufficient to give the same meter reading, V, and the corresponding vernier condenser reading $-C$ recorded. A summation of the absolute values of the two vernier condenser readings gives the value of ΔC_s. The grain sample is poured out and similar measurements of V_m, V, and ΔC_a are made using air as the dielectric after changing the variable condenser in the test cell an amount, C_x, to restore resonance. The dielectric constant (ε'), loss tangent (Tan δ), power factor (P.F.), loss factor (ε''), and conductivity (σ) can then be calculated from the following relationships†:

$$\varepsilon' = \frac{1.412\, C_x\,(b^2-a^2)\,\log_e b/a}{v} + 1$$

where C_x is in $\mu\mu f$, b is the inside diameter of the outer electrode, a is the outside diameter of the inner electrode of the test-cell in centimeters, and v is the volume of the grain sample in cubic centimeters.

$$\text{Tan } \delta = \frac{\dfrac{\Delta C_s}{\sqrt{(V_m/V)_s^2-1}} - \dfrac{\Delta C_a}{\sqrt{(V_m/V)_a^2-1}}}{2C_x}$$

where the subscript, s, is used for measurements made with the grain sample in the test-cell, the subscript, a, is used for measurements made with the test-cell empty or with air as the dielectric, and ΔC_s, ΔC_a, and C_x are in $\mu\mu f$.

$$\text{P.F.} = \frac{\tan \delta}{\sqrt{1+\tan^2 \delta}}$$

$$\varepsilon'' = \varepsilon' \tan \delta$$

$$\sigma = 0.556\, f\varepsilon''$$

where σ is in micromhos for a centimeter cube, and f is the frequency of the alternating field in megacycles.

A check on the apparatus and method in determining the dielectric properties of *AR* grade benzene yielded a value for the dielectric constant of 2.30 throughout the frequency range of 1 to 50 megacycles. Since this is the recognized value given by Hartshorn and Oliver (1929) the values determined for the dielectric constant may be considered satisfactory. The loss tangent for benzene was given correctly, to two decimal places, as zero. A suitable standard with a known higher value for the loss tangent was not found which could be used to check the loss tangent measurements throughout the entire frequency range. Good results were obtained in tests for the dielectric constant and loss tangent of castor oil at 10.9 mc.

The equipment described herein has adequate accuracy for practical use in studies concerned with the application of radio-frequency energy to grain and similar materials. The accuracy of the measurements could be improved, if desired, by more accurate calibration of the vernier condenser in the Q-Meter and the variable air condenser in the test cell. Use of an auxiliary constant-voltage transformer to provide a stable line voltage source is also desirable.

†Derivations of these formulas may be found in appended reference 5.

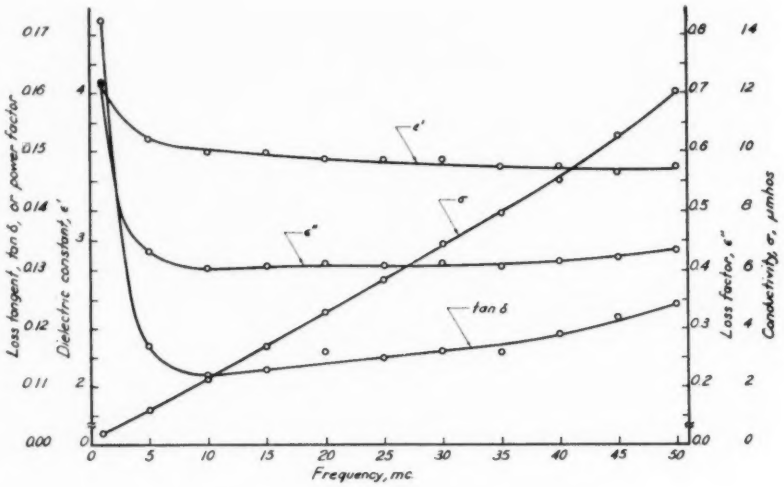

Fig. 5

The dielectric properties of a sample of Ezond barley (brought to 12.6 percent moisture) were obtained by this method and are shown in Fig. 5. Similar curves have been obtained for samples of wheat, corn, and oats.

For a more extensive treatment of the theoretical and experimental considerations of the method and equipment used, the reader is referred to the unpublished thesis of Nelson (1952).

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‡It should be noted here that errors have been made in publication of the first edition in equations (17.22) and (17.23). The correct formulas in the form found most convenient for calculation are as follows:

$$\varepsilon = \frac{1.412\,(C_2-C_3)\,(b^2-a^2)\,\log_e b/a}{v} + 1$$

$$\tan \delta = \left(\frac{C_1}{C_2-C}\right)\left(\frac{Q_2-Q_3}{Q_2Q_3}\right)$$

$$\text{P.F.} = \tan \delta / \sqrt{1+\tan^2 \delta}$$

$\sigma = 0.556\, f\varepsilon \tan \delta$ (micromhos, where f is in megacycles). These equations are derived by Nelson (1952).

Evaluating Irrigation Needs in Humid Areas

E. R. Allred and Robert Chen
MEMBER ASAE

IT IS difficult to evaluate all the factors that must be considered in determining the economical feasibility of supplemental irrigation in humid areas. In most cases, irrigation can be shown to be successful when applied to the higher valued truck and nursery crops. During recent years, however, more and more farmers are inquiring about the feasibility of making larger investments in order to irrigate general field crops. This more recent development has made it increasingly difficult for the irrigation engineer to offer sound information and advice.

In order to determine the economical feasibility of any irrigation system, one must first estimate the total annual cost and compare these costs with the expected returns. The annual cost of operating an irrigation system cannot be determined without having a reasonable estimate of the total amount of water required, and the number of irrigations needed per season. The purpose of this paper is to present a method, utilizing climatological data, that will assist extension workers and others dealing directly with the farmer in estimating these two important items affecting irrigation cost.

FACTORS DETERMINING NEED FOR IRRIGATION

Irrigation needs during a specified period will depend on the amount and distribution of rainfall, the residual soil moisture carry-over from previous precipitation and the rate of soil-moisture depletion through evapotranspiration processes. Information obtained from using mean climatic values is of limited usefulness, and such information may at times tend to be misleading. Consequently an irrigation engineer cannot be too concerned with the long-time average values of rainfall data et cetera. To obtain the best possible interpretation of climatological data, he must ferret out the extreme occurrences affecting his design.

Extreme variations in precipitation can best be shown by using actual daily readings. In the past, one of the most common methods of analyzing daily rainfall records, as a means of indicating the need or lack of need for irrigation in humid areas, has been by charting deficient periods for each year, strictly according to the rainfall pattern. The total number and occurrence of such periods then serve as an indication of the irrigation need. Various definitions as to what constitutes a moisture-deficient period have been suggested. Perhaps the most common definition of this type is that a drought begins on the eleventh day following a rainfall of ½ in (or more) in 24 hr, and continues until a rainfall of ½ in (or more) again occurs in 24 hr. Since this method has been so widely used in previous moisture deficiency studies, Fig. 1, showing the number of deficient periods that have occurred according to this definition, during the past ten years, in Minneapolis, is included for purposes of comparison. An analysis of the type shown in Fig. 1 does overcome certain disadvantages of other methods. Such an analysis, however, may at times be misleading because no provision can be made to include factors, other than rainfall, that affect irrigation need. A test of the reliability of such methods for evaluating drought periods can be made by comparing Fig. 1 with actual field studies made during 1951 and 1952. A field survey of irrigating farmers located in the Minneapolis area showed that no farmers irrigated alfalfa or corn during either 1951 or 1952, except for scattered instances where single applications were made late in the season, on extremely sandy soils. None of the farmers interviewed irrigated small grains during either year. The results of this field survey, therefore, do not agree with Fig. 1, especially not with the major deficient period shown to have existed during April and May of 1952. Also, actual moisture conditions in experimental irrigated fields, of the same crops, were observed through both growing seasons by means of gypsum blocks. At no time during 1951 was irrigation found to be necessary. Similarly, no irrigation was required on the corn or small grain plots during 1952. However, in 1952 one irrigation was needed on the alfalfa plots during early September. Obviously rainfall by itself it not a true indicator of the need for irrigation.

The method described in this study can be subdivided into three distinct operations: *(a)* Analyzing the available climatological data in such manner that a theoretical evaluation of the annual water deficiency can be made; *(b)* observing the results of field irrigation experiments, although limited in number, which accurately measure the extent of irrigation need, for specific years, and *(c)* correcting the theoretically computed deficiency for a given year so as to more nearly agree with the actual deficiency found to have existed during the same year by field experiments.

THEORETICAL ANALYSIS OF DATA

Each yearly set of computations begins on April 1 and follows through, on a daily basis, until September 30. The moisture condition for any specific day during the growing season is determined by

$$M_x = M_{x-1} + R_x - U_x \quad . \quad [1]$$

where M_x = available moisture remaining in the root zone at the end of any given day (x), in inches

M_{x-1} = available moisture carried over from previous day, in inches

R_x = rainfall received during day (x), in inches

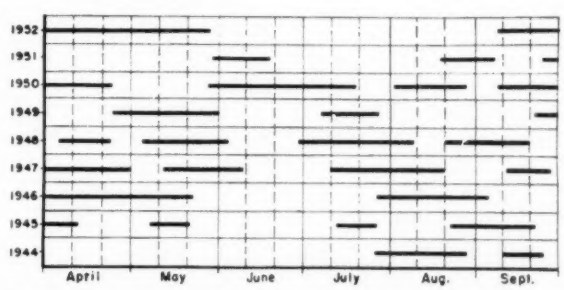


Fig. 1 Moisture deficient periods having occurred at Minneapolis, according to one-half-inch rainfall criterion

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Pittsburgh, Pa., June, 1953, as a contribution of the Soil and Water Division.

The authors — E. R. ALLRED and ROBERT CHEN — are, respectively, associate professor and research fellow, agricultural engineering department, University of Minnesota.

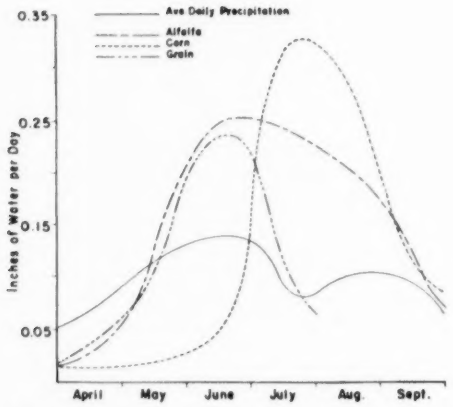


Fig. 2 Daily evapotranspiration as computed for a single year for various crops being grown in the Minneapolis area. (Computed by use of Blaney-Criddle method)

U_x = water used by evapotranspiration (consumptive use) during day (x), in inches.

Since equation [1] is solved for each day of the growing season, for each year being analyzed, considerable quantities of data must be handled. However, because in recent years the U.S. Weather Bureau has begun to extensively record climatological data on IBM punch cards, it was found all computations could be made quickly and efficiently by IBM digital machine methods. Such an analysis would obviously be impractical were it necessary to perform these computations manually. A brief explanation of the machine technique is given at the end of this paper.

The water used each day through evapotranspiration is computed theoretically. Several investigators have proposed methods of calculating the amount of water transpired from the plant and evaporated from the land surfaces. Perhaps the most common of these are Thornthwaite (16)*, Penman (7), and Blaney and Criddle (2). Although other methods might conceivably be used, the latter was used in this study, since it adapted itself well to the data available on the punch cards. Also, the Blaney-Criddle method suggests the use of consumptive-use coefficients for each type of crop grown, an important factor in a study of this type.

According to the Blaney-Criddle method of computing consumptive use,

$$U_x = (K_x P_x) T_x / 100 \quad [2]$$

where K_x = crop consumptive-use coefficient, for day (x)

P_x = percent of daytime hours of the year, for day (x)

T_x = mean temperature for day (x), in degrees Fahrenheit.

and Equation [1] becomes

$$M_x = M_{x-1} + R_x - (K_x P_x) T_x / 100 \quad [3]$$

The crop coefficients (K) used in equation [2], were based largely on the work of Blaney (3) and the field research conducted by Scofield and Howe (13), and Bowen (19), at the Scottsbluff Experiment Station, Scottsbluff, Nebr. These particular data were used since they were obtained under irrigated conditions, and in a climate more similar to Minneapolis than any other such data available. It was recognized that differences may exist in the growth characteristics of any crop, when being grown in the Scottsbluff and Minneapolis areas. Consequently care was exercised to correlate the timing of the peak moisture-demand period of each crop as closely as possible to local conditions. The seasonal variation in consumptive use for a single year, as computed for Minneapolis, by equation [2], is shown in Fig. 2. Because of the difficulty that may be experienced in selecting appropriate daily K values, and other uncontrolled factors, this method is not intended as a means of determining the time for irrigation, during any current season.

*Numbers in parentheses refer to the appended references.

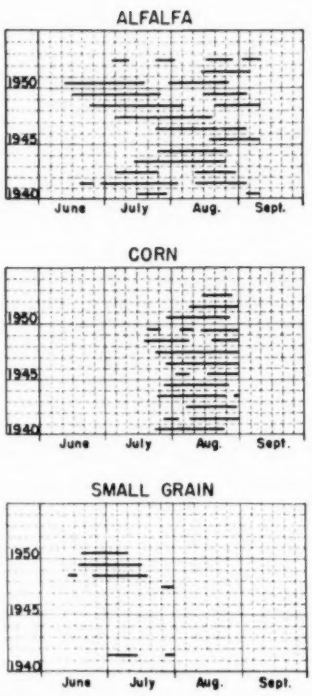


Fig. 3 Moisture deficient periods found to have occurred in Minneapolis during the years 1940-1952. (Note wide differences between Fig. 3 and Fig. 1)

The rainfall, R_x (of equation [3], is obtained directly from the official Weather Bureau cards. It was impossible in this study to allow for intensity or any rainfall characteristic other than the total amount received during the particular day. However, at no time was more than 2 in of rainfall per day used in the solution of equation [3]. Such may partially account for surface runoff, and other losses, accompanying the heavier rains.

Although the computations begin on April 1, it is first necessary to estimate the total amount of available moisture

TABLE 1. EXAMPLE OF THE DEFICIENCY COMPUTATION, AS MADE FOR ALFALFA, DURING AUGUST, 1951, AT MINNEAPOLIS

(1) Date	(2) Rainfall, in	(3) Mean temperature(t), deg F	(4) Consumptive use(u), in	(5) Moisture available (M),in	(6) Moisture deficiency (d),in
Carried forward from previous month				1.35	
1	---	77	0.24	1.11	---
2	---	77	0.24	0.87	---
3	---	69	0.21	0.66	---
4	---	69	0.21	0.45	---
5	0.19	63.5	0.19	0.45	---
6	---	69	0.21	0.24	---
7	0.70	68.5	0.21	0.73	---
8	---	69	0.21	0.52	---
9	---	67.5	0.20	0.32	---
10	---	70	0.21	0.11	---
11	---	63.5	0.19	---	0.08
12	0.24	62.5	0.18	0.06	---
13	0.14	60	0.18	0.02	---
14	---	65	0.19	---	0.17
15	---	67	0.20	---	0.20
16	0.21	67	0.19	0.02	---
17	---	65	0.19	---	0.17
18	---	64.5	0.19	---	0.19
19	0.19	77	0.22	---	0.03
20	---	6[illegible]	0.19	---	0.19
21	---	63.5	0.18	---	0.18
22	---	64.5	0.18	---	0.18
23	---	65 5	0.18	---	0.18
24	---	68	0.19	---	0.19
25	0.24	68	0.19	0.05	---
26	---	71.5	0.19	---	0.14
27	---	76.5	0.21	---	0.21
28	---	78.5	0.21	---	0.21
29	---	77.5	0.20	---	0.20
30	0.03	71.5	0.19	---	0.16
31	---	56	0.14	---	0.14
Total	1.94	68.1*	6.11	---	2.82

*Average

TABLE 2. METHOD USED TO CORRECT COMPUTED DEFICIENCIES FOR A PORTION OF THE MINNEAPOLIS CLIMATOLOGICAL RECORD AS ANALYZED IN THIS STUDY

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Alfalfa			Corn			Small grain		
Year	Total* computed deficiency, in	Corrected deficiency, in	Number irrigations needed	Total** computed deficiency, in	Corrected deficiency, in	Number irrigations needed	Total*** computed deficiency, in	Corrected deficiency, in	Number irrigations needed
1940	6.07	1.07	1	6.41	1.41	1	0.00	0.00	0
1941	11.64	6.64	3	8.29	3.29	2	2.18	1.18	1
1942	7.21	2.21	1	6.64	1.64	1	0.88	0.00	0
1943	7.93	2.93	1	8.33	3.33	2	0.00	0.00	0
1944	5.98	0.98	1	8.41	3.41	2	0.00	0.00	0
1945	6.00	1.00	1	6.33	1.33	1	0.00	0.00	0
1946	7.96	2.96	1	7.68	4.68	2	0.00	0.00	0
1947	11.54	6.54	3	10.59	5.59	2	0.66	0.00	0
1948	14.36	9.36	4	8.59	3.59	2	5.15	4.15	2
1949	12.19	7.19	3	7.34	2.34	1	5.09	4.09	2
1950	12.84	7.84	3	7.51	2.51	1	3.97	2.97	1
1951	4.75	0.00	0	5.02	0.00	0	0.00	0.00	0
1952	6.79	1.79	1	4.37	0.00	0	0.00	0.00	0

* To September 10th. ** To September 1st. *** To August 1st.

Correction: The total computed deficiency for corn, in 1946, in Table 2 (column 5) should read 9.68 in instead of 7.68 in.

in the soil on March 31 of each year. This estimation must be made since it represents the carry-over moisture value to be used in the moisture-balance equation [3] for the April 1 calculation. In certain areas, especially in the more arid regions, this would be a most difficult determination to make. Because of the relatively large amount of rainfall received each year in Minnesota, during the months of April, May and June, it was assumed that ample water was being held in the soil to raise the moisture content to field capacity on April 1. (In the event the soil moisture content was below field capacity on April 1, it is doubtful that later deficiency values would have been affected, since sufficient rainfall occurred each year during April, May and June to meet these conditions.) Obviously the total amount of available moisture at field capacity depends on the soil type and depth. Therefore, when a given amount of moisture is assumed to be present at the field capacity of a soil, the deficiency calculations are effectively being directed toward a specific soil type and condition. The estimated amount of available moisture existing in the root zone on March 31, in this study, was 5 in. This particular value was used because it approximated the field capacity of a typical irrigated Minnesota soil.

As the moisture-balance equation is solved for each day certain limits are placed on the available moisture. Regardless of the amount of rainfall occurring during any period, the available moisture M_x (equation [3]) cannot exceed the assumed field capacity. Neither does a negative value of M_x have any significance. The numerical value of M will vary, therefore, between the limits of zero, which occurs during periods of moisture deficiency, and the assumed field capacity (in this case 5 in), which occurs during periods of heavy rains. In this way, the carry-over moisture becomes zero on any day following a deficiency. The negative value thus obtained is instead transferred and punched in the proper deficiency columns on the card, and is considered to indicate the water deficiency, in inches, for that particular day.

Table 1 illustrates the "balance-sheet" type of calculation as made for alfalfa, during August, 1951, at Minneapolis. As with all years, the solution of the moisture-balance equation began in April, at which time 5 in of available moisture was assumed to be in root zone. The carry-over moisture from July 31 is shown to be 1.35 in. Although the upper limit was not reached during the particular month shown, the available moisture (M), for the year, ranged between the field capacity (5 in) and zero. Deficiencies occurred only on those days during which M was depleted.

The deficient periods found by this method to have occurred in Minneapolis during the years 1940-1952, are shown in Fig. 3. Since consumptive-use requirements are different for each crop, each chart represents a separate set of computations. During no year and with no crop was a deficient period found to have occurred before June 1. It is evident that the seasonal variation in consumptive-use requirements, shown in Fig. 2, affect the drought pattern of the various crops considerably. Small grains, for example, due to early maturity, completely escape most of the deficient periods, while in most years alfalfa requires additional moisture.

In comparing the occurrence of drought periods, by the two methods as shown in Figs. 1 and 3, a large variation is seen to exist. However, there does appear to be a slight similarity between the July-September period of Fig. 1 and the alfalfa deficiency chart of Fig. 3. This is perhaps due to the heavy and prolonged water requirements that occur for alfalfa during most of the growing season. Under such conditions the available moisture during the later part of the growing season is largely dependent on the day-to-day rainfall, and in many respects the two methods become alike. This, however, does not hold true earlier in the season at

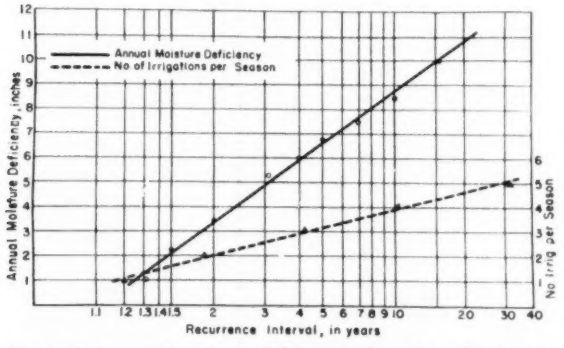

Annual Moisture Deficiency
No. of Irrigations per Season
Annual Moisture Deficiency, inches
No. Irrig. per Season
Recurrence Interval, in years

Fig. 4 Frequency of moisture deficiency and number of irrigations per season for alfalfa (based on a 62-year climatological record at Minneapolis, with a soil having 5 in available moisture in the root zone, at field capacity)

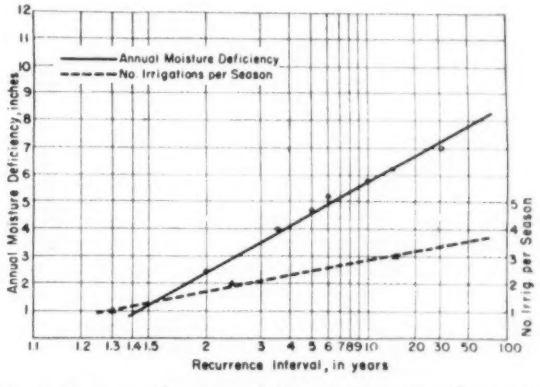


Fig. 5 Frequency of moisture deficiency and number of irrigations per season for corn (based on a 62-year climatological record at Minneapolis with a soil having 5 in available moisture in the root zone, at field capacity)

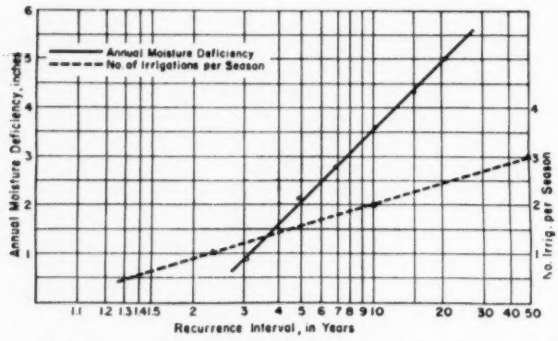

Annual Moisture Deficiency
No. of Irrigations per Season
Annual Moisture Deficiency, inches
No. Irrig. per Season
Recurrence Interval, in Years

Fig. 6 Frequency of moisture deficiency and number of irrigations per season for small grain (based on a 62-year climatological record at Minneapolis, with a soil having 5 in available moisture in the root zone at field capacity)

which time a deficiency in rainfall may be compensated for by an ample residual moisture supply in the soil, a factor not considered in Fig. 1.

Table 2 shows the total deficiencies as computed for a portion (1940-1952) of the Minneapolis climatological record being analyzed. (A total of 62 years, 1891-1952, of climatological record were analyzed in this study.) Such deficiencies, shown in columns 2, 5 and 8, were obtained for alfalfa, field corn and small grains. These values are merely considered to represent a numerical yardstick or index from which actual deficiencies can later be estimated.

COMPUTED DEFICIENCY FOR A GIVEN CROP

The total computed deficiency for a given crop is obtained by a summary punching process totaling the appropriate columns as calculated and punched on the cards. By proper control board wiring, such a total can be obtained at any time during the growing season by inserting a summary card at the desired position in the deck. Even though the evapotranspiration processes may continue until late into the fall with many crops, a stage of maturity is generally reached where additional moisture is not always desirable. When such conditions occur, the deficiency is totaled at a specified date rather than running to the end of the season. An example of this situation occurs with field corn, which reaches full milk stage by late August in the Minneapolis area. Considerable doubt exists as to the wisdom of irrigating field corn after this stage is reached, since it may tend to delay maturity and does not appear to result in any increase of yield. In such cases it would be inadvisable for the farmer to irrigate, even though the natural rainfall may not fulfill maximum evapotranspiration needs during September. For this reason, the deficiencies for small grain, corn and alfalfa were totaled as of August 1, September 1, and September 10, respectively.

CORRELATION OF FIELD DATA

Studies of the actual need for irrigation were made for the years of 1951 and 1952, through the use of experimental field plots. Frequent observations of moisture content were made by means of gypsum blocks installed in medium to light-textured soils having approximately 5 in of available moisture in the root zone at field capacity. A limited amount of field data were also obtained during 1949 and 1950. These data were of questionable value, however, since the only criterion used to determine the time and need for irrigation was by the appearance and feel of the soil. During 1951 no irrigation was needed on the alfalfa plots, since at no time did the moisture level drop below 67 percent available. In 1952, however, alfalfa required one irrigation in early September. Table 2 shows that the computed deficiencies obtained for alfalfa, in 1951 and 1952, were 4.75 in and 6.79 in, respectively. Also, during both 1949 and 1950, approximately 6 in of irrigation water were applied to the alfalfa plots. Based on these data it was assumed that the computed deficiency for each year was approximately 5 in too high, as compared with the actual field data. A corrected deficiency value was thus obtained (Table 2), by subtracting a correction factor of 5 in from each of the total computed deficiencies.

Similar field studies on corn plots found no irrigation was needed during 1952. On August 4, 1951, the moisture level dropped to 67 percent available and irrigation was planned for the following day. During the night, however, a rain occurred and the irrigation was not applied. Table 2 shows the computed deficiencies for corn in 1951 and 1952

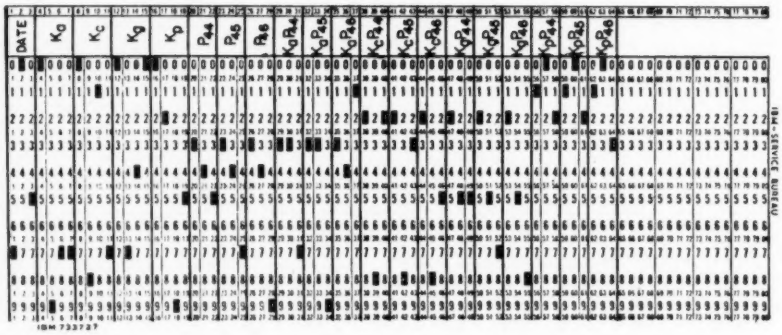
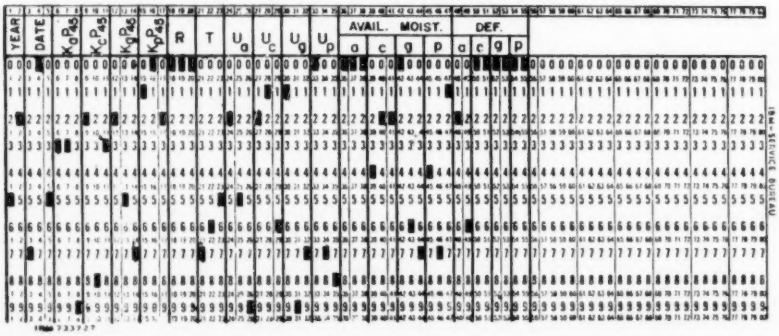


Fig. 7a *(Above)* and Fig. 7b *(Below)* Sample punch cards as used in this study, showing relative position of pertinent data



to be 5.02 in and 4.37 in respectively. Also, records of experimental field data taken in 1949 and 1950 show that approximately 3 in of water were applied to the corn plots during these years. These data indicate that a correction factor of 5 in is also needed to reduce the computed deficiency for corn in order to make it more nearly agree with the actual field data. (No explanation can be given at this time as to the reason for the correction factors of both alfalfa and corn being the same.) Table 2 again shows how these corrections were made.

An attempt was made to obtain a similar correction factor for small grains. However, due to the greater than average rainfall which occurred during 1951 and 1952, no satisfactory correction factor could be established. Based strictly on limited data observed during 1948, 1949, and 1950, it appears that a correction of approximately one inch (reduction) is necessary. Further field data are needed, however, to fully justify this assumption. Should future experimental field data indicate any of the above correction factors to be in error, adjustment might be made at that time.

Having estimated the total water deficiency for each crop, it was then found that a reasonable estimate of the number of irrigations required each season could be made. By assuming a corrected deficiency of 0-3 in to represent one irrigation; 3-6 in as two irrigations; and 6-9 in as three irrigations, et cetra, it was found that the estimated number of irrigations correlated very well with the actual number made during those years field data were taken. Most estimates made of the number of irrigations required each year agreed with the actual number applied. In no case was the variation greater than one irrigation per year. Based on this limited observance, the number of irrigations needed for each crop per year were estimated for the entire 62 years of climatological data.

SUMMARIZATION OF DATA

A brief review of the total corrected deficiencies obtained for the 62 years of record at Minneapolis showed irrigation was unnecessary for alfalfa, corn and small grains during 16, 23 and 56 percent of the years, respectively. The probability of needing any specified amount of water each year for each of these crops, can be determined by Figs. 4, 5 and 6. For example, Fig. 5 shows that with corn one can expect to have 4 in of moisture deficiency, one out of every 3.5 years. Similarly the probability of having a 6-in deficiency with corn is reduced to one year out of every twelve.

Studies of the type herein described are planned for several selected stations in Minnesota. Since the state extends approximately 200 miles east-west and 400 miles in a north-south direction, the climate, length of growing season and soils vary considerably. Following such studies, it is hoped that individuals in these different areas, who are considering irrigation of field crops, can be given more definite recommendations concerning its economical feasibility.

ADAPTING CLIMATOLOGICAL DATA TO IBM MACHINE METHOD

A moisture-deficiency analysis of the type described in this paper is begun by selecting a sufficient number of punch cards to furnish one card for each day of the growing season. These cards, referred to as master cards, contain basic data of such a nature that, for a given day, does not change from year to year. Fig. 7*a* illustrates a typical master card for July 5 and the data punched thereon is valid for July 5 of any year. The card shown is labeled to indicate the type of data and their position on the card. For example, in columns 4-19 inclusive are punched the daily K values of the various crops. In this particular study alfalfa, corn, small grain and potatoes were investigated. (Although potatoes was one of the crops originally investigated in this study, no results are shown since insufficient data have been taken to justify definite conclusions at this time.) The data punched in columns 20-28, inclusive, denote the percent of daytime hours of the year included in that particular day (18). Climatological data from stations located in three latitudes (44, 45, and 46 deg) are shown on this card. Since information of the type listed in columns 4 to 28 is of an original nature, it is necessary to punch this portion of the master cards manually.

The first actual calculations† made are the products shown in columns 29-64, Fig. 7*a*. These values are needed in order to include the various combinations of crop and latitude variables being investigated. Several such products can be computed and punched with a single passage of the cards through the machine. Additional crops and/or latitudes might be included, if desired, to fill the remaining space on the card.

With the exception of M_{x-1} all remaining data to be used in solving equation [3] are actual climatological data as recorded for given days and years. Consequently further computations must be made on a daily basis requiring a separate deck of cards for each year. A sample of such a card, hereafter referred to as D cards, is shown in Fig. 7*b*.

In preparing a set of D cards for a given season, it is first necessary to transfer all desired data from the official U.S. Weather Bureau cards to a new deck. In this case, the year, date, precipitation (R) and mean daily temperature (T) were transferred. Since the Weather Bureau data being used in this particular case pertains to Minneapolis, only those products on the M cards concerned with the 45 deg latitude are transferred to the D cards. It can be seen from Fig. 7*b* that all data (on D cards) included in columns 1 to 23 inclusive are merely transferred from cards already punched. The theoretical amount of water used during the day by the various crops (U_a, U_c, U_g, etc.) can now be computed and punched in the appropriate columns on the D card, thus solving equation [2]. As was true with the products on the master cards, several U values can be obtained with a single passage of the cards through the machine.

Having evaluated the consumptive-use of a given crop, the moisture-balance equation can now be solved for each day. During those days when this equation is positive, its value is punched as available moisture in column 36-47 (Fig. 7*b*). Negative values are considered as deficiencies and are punched in columns 48-55. The yearly computed deficiencies for any crop can then be obtained by totaling the appropriate deficiency columns.

An estimate of the time required to make the computations, in an analysis of this type, may be of particular interest. Assuming the basic data, such as the consumptive-use coefficients and the percent of daylight hours, have been assembled, the machine time required to complete all operations necessary in determining the total deficiency (Table 2) for four crops, is approximately *(Continued on page 619)*

†All computations in this study were made with the IBM calculating punch machine (type 602-A).

Resistance of Grains and Seeds to Air Flow

C. K. Shedd
LIFE FELLOW ASAE

THIS paper includes new data on resistance of grains and seeds to air flow. It also includes an absract of data published in reference (1)* and it includes or supersedes data published in reference (2). Other data on resistance of grains to air flow may be found in appended references.

The apparatus used for making the tests on ear corn was described in publication (1). It consisted of a bin about 7 ft square and 13 ft deep with false perforated floor. Air flow was measured by Pitot tube in a long, straight pipe.

The apparatus used for making the tests on shelled and threshed grains and seeds was described in publication (2). It consisted of a cylindrical steel bin of 8-in diameter and 9 ft deep, with false perforated floor. Air was supplied and measured by a displacement method.

Fig. 1 is a graphical presentation of pressure-flow data on log-log scale for the various grains. Data shown in Fig. 1 are for loose-filled grain of good quality and clean, that is, containing little foreign material with the exceptions noted in Table 1. The moisture content of each lot is recorded in Fig. 1 except red clover and alsike clover. Both of these lots were dry seed.

Pressure-Flow Formulas. The curves shown in Fig. 1 are more or less convex upward. If they were straight lines the pressure-flow relationship could be expressed by formulas of the form $Q=aP^b$ in which

Q = air flow, cubic feet per minute per square foot of floor
P = pressure drop per foot depth of grain, inches of water
a and b = constants for any one lot and condition of grain
a = the value of Q when $P=1$
b = the slope of the curve on the chart.

The general slope of the curves is greater for fine than for coarse materials. For example, if we take the slope of the curves on Fig. 1 as straight lines from $Q=10$ to $Q=40$, the values of a and b are:

For lot 2 ear corn,	$a=300$,	$b=0.53$
For shelled corn,	$a=62$,	$b=0.68$
For wheat,	$a=32$,	$b=0.80$
For sericea lespedeza,	$a=9.5$,	$b=0.88$

Because of the convexity of the curves shown in Fig. 1, formulas such as just described will fit the curves for only a narrow range of rates of air flow; and, if used to calculate pressures for rates of flow above or below this range, they may give results that are considerably in error. For this reason, the utility of such formulas is questionable.

Density of Grain. Each lot of shelled or threshed grain or seed was tested with two methtods of filling the bin which may be called loose fill and packed fill. Loose filling was done by pouring the grain into a funnel, the outlet of which was held just above the surface of grain in the bin. Packed fill was made by pouring the grain into place from one to two feet above the grain surface without use of the funnel and then tapping the bin wall with a wooden mallet to settle the grain after each foot of depth was added. A record was kept of the weight of grain added for each foot increase in depth.

It is not known just how the density of grain in these tests compares with the density in a full-scale bin as normally filled, but it is thought that the grain, at least in some parts of an ordinary bin, would be packed to about the density of the packed fill in the test bin.

Effect of Depth. Pressure-flow data are given in Fig. 1 as the average pressure drop per foot depth of grain. In most of the tests this is one-ninth of the pressure drop measured in 9-ft depth. Exceptions were as follows: blue lupine, depth of 4 ft; kobe lespedeza, 4 ft; crimson clover, 1.98 ft; alfalfa, 3 ft; sericea lespedeza, 4 ft; red clover, 2 ft; alsike clover, 3 ft. Also, because of the limitation of the test apparatus to about 8 in total pressure drop, the full 9-ft depth of grain could be used only for grains and rates of air flow resulting in a pressure drop per foot of a little less than one inch. For grains having a higher pressure drop, a reduced depth was used for tests of high rates of flow and the bin was filled to full depth for lower rates of flow.

It might be expected that pressure drop per foot would not be uniform but might be more in the lower part than in the upper part of the bin. To study the uniformity of pressure drop, air pressure was measured at each foot of depth of shelled and threshed grains. Comparing the average pressure drop in 9 ft of depth with the average in the top 4 ft, the pressure drop per foot of depth was a little greater in the 9-ft depth in nearly all tests; but the difference was not the same percentage of total pressure in different lots of grain. In shelled corn lot 4, the difference was 1.1 percent of the total pressure for loose fill and 0.2 percent for packed fill. In other shelled corn tests, the difference ranged up to a little over 5 percent. There were only a few tests of relatively coarse materials in which this difference exceeded 8 percent.

These observations indicate that the pressures recorded in Fig. 1 and Table 1 may be a little higher than they would be when air is forced through shallower depths than 9 ft. This difference is less than the pressure variations that may be caused by differences in grain characteristics and in packing of the grain, which cannot be estimated precisely.

Effects of Moisture, Foreign Material and Density. Most of the grains were tested also at moisture contents other than shown in Fig. 1 and some were tested with additional amounts of foreign material. When data from tests of shelled and threshed grains under these various conditions were plotted, the curves for any one grain were substantially parallel. This means that the pressures were in substantially the same ratio to each other throughout the range of tested rates of air flow. Taking advantage of this characteristic of the data, a single curve is used for each grain in Fig. 1 which, as stated above, shows data for loose fill of clean,

This paper was prepared expressly for AGRICULTURAL ENGINEERING. Approved as Journal Paper No. J-2333, Iowa Agricultural Experiment Station, Project No. 587.

The author—C. K. SHEDD—is senior agricultural engineer, division of farm buildings and rural housing (BPISAE) U.S. Department of Agriculture.

*Numbers in parentheses refer to the appended references.

relatively dry grain. Ratios to be used to find pressures for other conditions are given in Table 1, which also gives the density in pounds per cubic foot and describes the different lots of grain tested. Ear corn was an exception to the above statement. Therefore, a curve is shown for each lot tested

It was found that the density was less and the resistance pressure for a given rate of air flow was less for a lot of grain at 20 percent or higher moisture than for the same lot of grain and the same method of filling after drying to lower moisture content. In a batch-drying operation, we may assume that the grain will be pack-filled when containing high moisture. As it dries, the shrinkage of the grain tends to loosen the fill so at the end of the drying operation we may have a loose fill of dry grain. Loosening of the fill tends to offset the increase in pressure that would be expected with reduction in moisture content.

Foreign material mixed with the grain tends to increase the resistance to air flow if the foreign material is finer than the grain and to reduce the resistance to air flow if it is coarser than the grain.

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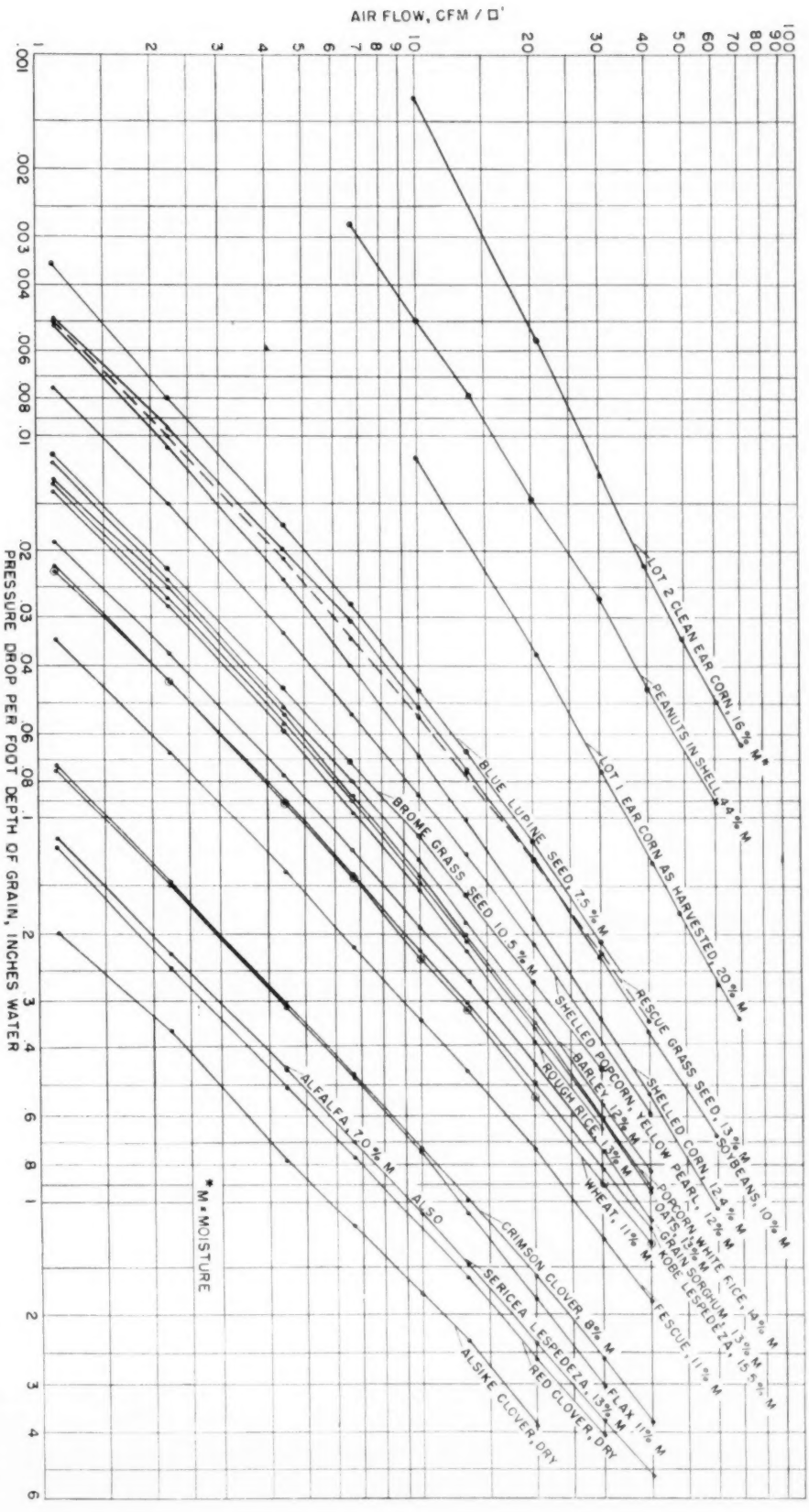
AIR FLOW, CFM / □'
PRESSURE DROP PER FOOT DEPTH OF GRAIN, INCHES WATER
*M = MOISTURE
LOT 2 CLEAN EAR CORN, 16% M*
PEANUTS IN SHELL, 4% M
LOT 1 EAR CORN AS HARVESTED, 20% M
BLUE LUPINE SEED, 7.5% M
BROME GRASS SEED, 10.5% M
RESCUE GRASS SEED, 13% M
SHELLED POPCORN, YELLOW PEARL, 12.4% M
SHELLED CORN, 12% M
SOYBEANS, 10% M
BARLEY, 12% M
ROUGH RICE, 12% M
POPCORN, WHITE RICE, 14% M
WHEAT, 11% M
OATS, 13% M
GRAIN SORGHUM, 13% M
KOBE LESPEDEZA, 15.5% M
ALFALFA, 7.0% M
ALSO
CRIMSON CLOVER, 8% M
SERICEA LESPEDEZA, 13% M
FESCUE, 11% M
FLAX, 11% M
RED CLOVER, DRY
ALSIKE CLOVER, DRY

Fig. 1 Resistance of loosely filled clean dry grains and seeds to air flow

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TABLE 1. RESISTANCE TO AIR FLOW OF GRAINS AND SEEDS IN VARIOUS CONDITIONS IN RELATION TO DATA SHOWN IN FIG. 1

Description of lot of grain (arranged in order of resistance as in Fig. 1)	Loose fill		Packed fill	
	Lb per cu ft	Pressure ratio*	Lb per cu ft	Pressure ratio*
Ear Corn				
Lot 2. Clean ear corn, medium size ears, no husks, shelled corn or foreign material		1.00		
Lot 1. Ears, 94.6%; loose husks and silks, 1.2%; husks attached to ears, 0.5%; shelled corn, 3.7% by weight		1.00		
Peanuts in Shell				
Lot 1-C. Lot 1-B dried. Moisture, 4.4%	14.0	1.00	14.9	1.54
Lot 1. Virginia type. "Farmers' stock" (uncleaned, ungraded, as they came from the picker), foreign material, 8.5%; shelled nuts, 1.4%; moisture, 9.0%	12.4	.98	13.7	1.66
Lot 1-A. Lot 1 plus water. Moisture about 18%	12.8	.94	13.6	1.38
Lot 1-B. Lot 1-A cleaned and dried. Moisture, 10.6%	13.8	.90	14.7	1.36
Blue Lupine Seed				
Lot 1. Foreign material, 0.5%; test weight, 57.3 lb per bu; moisture, 7.5%	47.2	1.00	49.6	1.45
Lot 1-A. Lot 1 plus water. Moisture, 19.8%	45.0	1.00	47.5	1.51
Rescue Grass Seed				
Lot 1. Clean seed. Test weight, 13.8 lb per bu; moisture, 13.1%	11.9	1.00	13.7	1.65
Lot 1-A. Lot 1 plus water; moisture, 15.6%	11.8	.92	13.6	1.57
Soybeans				
Lot 1. Lincoln variety; no damage; no foreign material; splits, 1.0%; test weight, 58.5 lb per bu; moisture, 10.2%	47.4	1.00	49.9	1.41
Shelled Yellow Dent Corn				
Lot 4. Damage, 0; cracked grain and foreign material, 0; test weight, 56.5 lb per bu; moisture, 12.4%	45.6	1.00	47.7	1.34
Lot 4-A. Lot 4 plus water. Moisture, 15.8%	46.0	.99	47.8	1.28
Lot 4-B. Lot 4 plus water. Moisture, 21.1%	42.7	.62	44.4	.80
Lot 4-C. Lot 4 dried to 9.9% moisture	46.2	1.11	48.0	1.42
Lot 3. Damaged kernels, 3.0%; cracked grain and foreign material, 0.5%; test weight, 57.0 lb per bu; moisture, 12.8%	45.0	.88	47.4	1.21
Lot 3-C. Lot 3 plus 2% cracked grain and foreign material†	44.9	1.03		
Lot 3-D. Lot 3 plus 5% cracked grain and foreign material†	45.3	1.34	47.8	2.20
Shelled Popcorn, Yellow Pearl Type				
Lot 1. Damage, 0; foreign material, 0; test weight, 64 lb per bu; moisture, 12.0%	51.2	1.00	54.0	1.40
Popcorn, White Rice Type				
Lot 1. Damage, 0; foreign material, 0; test wt., 63 lb per bu; moisture, 14.2%	50.7	1.00	52.9	1.28
Lot 1-A. Lot 1 plus water. Moisture, 17.4%	48.8	.74	51.2	1.02
Brome Grass Seed				
Lot 1. Cleaned seed but still contained a small undetermined amount of trash. Moisture, 10.5%	8.8	1.00	9.9	1.64
Barley				
Lot 1-A. Damage, 0; foreign material, trace; test weight, 45.3 lb per bu; moisture, 11.8%	37.3	1.00	39.9	1.46
Lot 1-B. Lot 1-A plus water. Moisture, 20.2%	36.7	.96	39.4	1.48
Lot 1. Lot 1-A before cleaning. Foreign material, 1.3%; moisture, 11.6%	35.8	1.00	38.6	1.40
Oats				
Lot 1-A. Lot 1 plus water Moisture, 13.2%	33.1	1.00	35.8	1.54
Lot 1. Damage, 0; foreign material, 0.1%; test weight, 39 lb per bu; moisture, 8.4%	33.0	1.05	36.1	1.73
Lot 1-B. Lot 1 plus water. Moisture, 19.2%	31.9	.91	34.8	1.36
Lot 2. Damage, 0; foreign material, 0.5%; test weight, 32 lb per bu; moisture, 14.7%	27.0	.94	29.3	1.38
Lot 2-A. Lot 2 plus water. Moisture, 18.8%	27.2	.87	29.4	1.24
Rough Rice				
Lot 1. Damage, 0; foreign material, 0; hulled whole kernels (head rice), 2.6%; hulled broken kernels (brewer's rice), 1.6%; whole kernels with hulls on (rough rice), 95.8%; moisture, 13.4%	38.2	1.00	40.6	1.32
Lot 1-A. Lot 1 plus water. Moisture, 20.7%	38.7	.78	41.3	1.16
Grain Sorghum				
Lot 1. Damage, 0; cracked grain and foreign material, 4%; test weight, 58 lb per bu; moisture, 13.1%	47.4	1.00	50.0	1.41
Lot 1-A. Lot 1 plus water. Moisture, 18.1%	46.0	.88	48.3	1.23
Lot 1-B. Lot 1-A cleaned and dried. Moisture, 8.5%	47.1	.91	50.0	1.34
Lot 1-C. Lot 1-B plus water. Moisture, 15.5%	45.9	.79	48.8	1.14

*To find pressure drop per foot depth of grain, read the pressure from Fig. 1 and multiply it by this ratio.

†Cracked grain and foreign material added was shelled corn screenings that passed a 12/64-in round-hole dockage sieve.

Description of lot of grain (arranged in order of resistance as in Fig. 1)	Loose fill Lb per cu ft	Loose fill Pressure ratio*	Packed fill Lb per cu ft	Packed fill Pressure ratio*
Kobe Lespedeza				
Lot 1-B. Cleaned seed in hulls. Damage, 0; light seed and foreign material, est. 5%; test weight, 24.7 lb per bu; moisture, 15.5%	20.1	1.00	21.9	1.45
Lot 1-C. Lot 1-B dried to 7.0% moisture	20.5	1.05	22.2	1.60
Lot 1. Uncleaned seed. Damage, 0; foreign material, 54.0%; moisture, 10.9%	19.2	1.32	21.1	2.12
Lot 1-A. Lot 1 plus water. Moisture, 17.0%	18.7	1.11	20.6	1.81
Wheat				
Lot 1. Damage, 0; foreign material, 0; test weight, 60 lb per bu; moisture, 11.3%	49.8	1.00	51.8	1.30
Lot 1-A. Lot 1 plus water. Test weight, 55.6 lb per bu; moisture, 19.5%	46.5	.72	48.8	1.00
Fescue Grass Seed				
Lot 2. Damage, 0; foreign material, 0; test weight, 22.0 lb per bu; moisture, 10.8%	19.9	1.00	21.8	1.45
Lot 2-A. Lot 2 plus water. Moisture, 16.9%	19.9	.84	21.6	1.13
Lot 1. Uncleaned seed. Damage, 0; foreign material, 5%; test weight, 19.8 lb per bu; moisture 13.0%	17.9	.70	19.6	1.10
Lot 1-A. Lot 1 plus water. Moisture, 16.2%	18.0	.71	19.8	1.08
Crimson Clover Seed				
Lot 1-B. Cleaned seed. Damage, 0; small grass seed and foreign material, est. 3%; test weight, 58.5 lb per bu; moisture, 8.0%	47.4	1.00	51.3	1.44
Lot 1. Uncleaned seed. Damage, 0; foreign material, coarse 24%, fine 9%; moisture, 10.0%	29.5	.60	32.1	1.01
Lot 1-A. Lot 1 plus water. Moisture, 18.0%	29.4	.51	32.3	.88
Flax Seed				
Lot 1-A. Damage, 0; foreign material, 0.4%; moisture, 11.0%	42.4	1.00	44.4	1.27
Lot 1-B. Lot 1-A plus water. Test weight, 46 lb per bu; moisture, 15.4%	39.1	.53	40.1	.62
Lot 1. Same as lot 1-A except moisture, 5.6%	43.5	1.34	45.3	1.57
Alfalfa Seed				
Lot 2. Pure seed, 99.58%; crop seed, .06%; weed seed, .04%; inert material, 0.32%. Test weight, 61.1 lb per bu. Moisture, 7.0%	50.2	1.00	53.6	1.46
Sericea Lespedeza Seed				
Lot 1-C. Lot 1-B recleaned. Damage, 0; foreign material, 0; test weight, 60.6 lb per bu; moisture, 13.0%	49.1	1.00	51.8	1.50
Lot 1-B. Cleaned seed. Damage, 0; seed in hulls, 15%; light seed and chaff, 3%; moisture, 13.0%	42.3	.80	45.2	1.21
Lot 1. Uncleaned seed. Damage, 0; foreign material, 15%; moisture, 9.5%	44.0	1.03	46.6	1.55
Lot 1-A. Lot 1 plus water. Moisture, 15.0%	39.6	.61	43.2	1.03
Red Clover Seed				
Lot 1. Clean, dry seed	50.1	1.00	52.2	1.42
Alsike Clover Seed				
Lot 1. Clean, dry seed	50.2	1.00	53.4	1.49

Evaluating Irrigation Needs

(Continued from page 615)

one man-hour per year of record. The analysis of a 60-year record, therefore, should be approximately 60 man-hours. After more experience with the equipment, this time might be reduced by as much as 20 percent.

It is beyond the scope of this paper to fully explain or illustrate the panel-board wiring diagrams needed to perform the calculations as described. Such diagrams, however, will be made available to those readers interested in securing them.

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Trainees Not Engineers

WHENEVER engineering professionalism has been discussed or written about in recent years, it has been a general practice to compare engineering with the professions of law and medicine. In both cases, but particularly in the medical profession, the graduate must serve an apprenticeship. Engineering graduates are reluctant to do so. A high percentage of young men with BS degrees already consider themselves professional engineers. But for the most part, they are trainees, not engineers, though they generally dislike that title. For this reason, industry must not only guide the engineering novice toward professional competence, but we must first make him aware that such status is not gained merely through possession of a degree.—R. E. Burton in *Mechanical Engineering* for June, 1953.

Horizontal Self-Feeding Silos

Merle L. Esmay and Donald B. Brooker
MEMBER ASAE ASSOC. MEMBER ASAE

A NEW approach is needed to the problem of storing and handling of silage. It has been stated by Deane G. Carter* that for many years improvement of silos has consisted of finding a better wall treatment, adding a roof, putting in more reinforcement, or planning a simpler method of erection. Important as these may be for durability, appearance, economy, or safety, it is Carter's thought that the real challenges are to find ways and means to prevent the usual 5 to 10 percent spoilage, to perfect a self-feeding method, to devise a mechanism for removal of silage, and to find economical ways to store, preserve, and handle large amounts of grass silage.

The horizontal silo lends itself to these improvements. Silos in this category range from the stack to the permanent concrete above-ground or below-ground silos. The stack is a type of storage in which the lack of storage structure expense is generally counterbalanced with a loss of quality in the silage. One step better than this is the below-ground unlined trench which does give some sidewall protection against spoilage, but still can be considered as only a temporary structure. The permanent horizontal silo, either above-ground or below-ground, with concrete floor and walls, fits in well with a long-time silage-feeding program.

The annual report of the Missouri Agricultural Engineering Extension Service for 1952 indicates a trend to horizontal silos. In 1952, there were 12,794 silos constructed in Missouri. Of these, only 662 were permanent upright silos, and 202 were of permanent horizontal types. The remaining 11,930 were temporary horizontal silos. These data indicate an increased silo-building activity in Missouri brought on partly by a drought year. It is significant, however, that many farmers who used the temporary horizontal silos for the first time because of the drought, are enthusiastic about them and are making plans for improving them with concrete floors and sidewalls. This will provide all-weather operation and added convenience, so they can include silage in their longtime feeding program.

A detailed study of some existing horizontal silos in Missouri was made during the winter of 1952-53, to obtain information on adaptability to self-feeding operations, economy of concrete construction, mechanical handling of silage with available equipment on the farm, optimum silo dimensions, and protective coverings.

Inefficiency of feeding operations in and around the buildings is the limiting factor in determining the number of livestock a farmer can care for. In many instances a well-balanced farm program calls for more than this number of livestock, inasmuch as the farm is capable of producing the extra feed, and the farmer with the present-day mechanized field equipment is able to harvest and store it. The horizontal silo with its possibilities of contributing to higher efficiency through self-feeding, or utilization of mechanized equipment such as the tractor manure scoop, appears to offer a practical solution to this problem.

CONSTRUCTION

Unlined trench silos constructed throughout Missouri during the summer of 1952 averaged approximately 125 tons in capacity. Practically all of them exceeded the following minimum dimensions: 8 ft wide at the bottom, 6 ft deep, and 100 ft long. The side slopes of these unlined trenches varied, depending upon the nature of the soil, from almost vertical to one-to-one slopes. The cost of digging these trenches was approximately 55¢ per ton of silage capacity.

Silo Floors and Walls. Of the twenty-two horizontal silos selected for study during the winter of 1952-53, eleven had concrete walls, one had plastered walls, and two had wood plank walls. Although the winter of 1952-53, being quite

This paper was presented at a meeting of the Mid-Central Section of the American Society of Agricultural Engineers at St. Joseph, Mo., March, 1953.

The authors—MERLE L. ESMAY and DONALD B. BROOKER—are, respectively, professor and assistant professor of agricultural engineering, University of Missouri.

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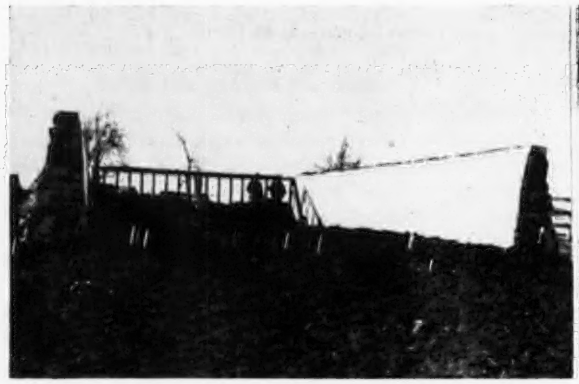

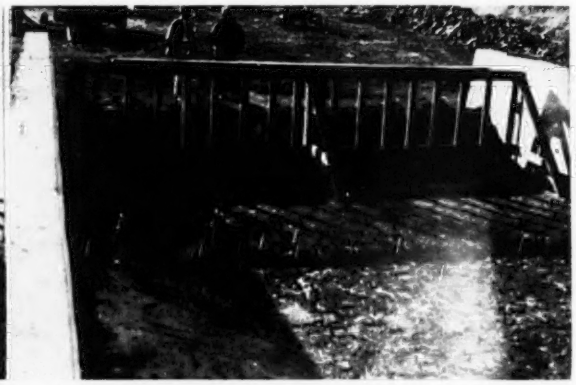

Fig. 1 *(Left)* A native-stone above-ground horizontal silo, with 20-ft x 50-ft x 4-in floors, two 50-ft x 6-ft x 3½-ft walls plastered on the inside, approximately $300 for materials, and 90-ton capacity • Fig. 2 *(Right)* Self-feeding gate of silo in Fig. 1. A 20-ft gate was used successfully to feed 45 dairy cattle including some young stock. As shown, the silage is nearly fed out

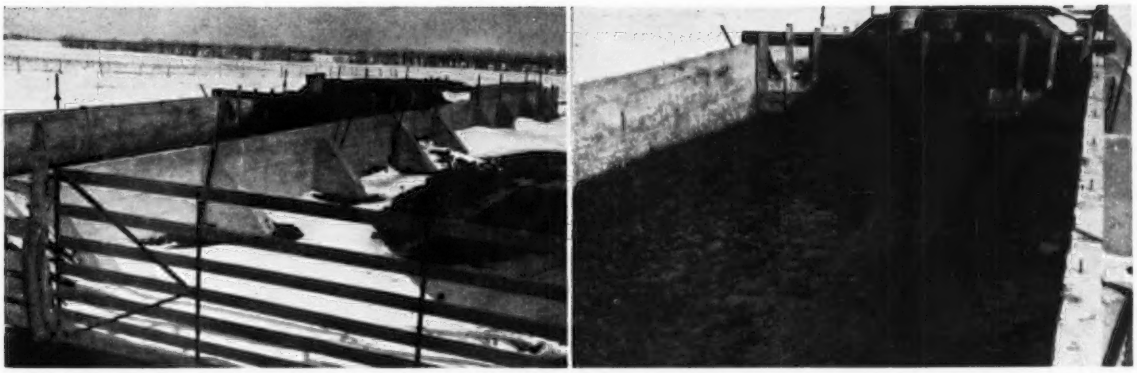

Fig. 3 *(Left)* A concrete horizontal silo with 16-ft x 90-ft x 4-in floor, two 90-ft x 3½-ft x 6-in walls, 18 4-ft x 6-in pilasters, approximately 37 cu yd of concrete, and 90-ton silage capacity • Fig. 4 *(Right)* Self-feeding gate of silo shown in Fig. 3. Eleven openings were sufficient to feed 33 young stock. Note edges of silage were not well packed

dry and mild, was favorable for the use of the many unlined trench silos in Missouri, most farmers were convinced that for continued use of the silos year after year it would pay to put concrete floors in them. With most soils in Missouri, which are not generally of the free standing type, it was also evident that for continued use the sidewalls must also be lined either the second or third year.

A 4-in concrete floor for a trench 8 ft deep requires approximately $\frac{1}{10}$ cu yd of concrete per ton of silage storage capacity. Such a floor is easily constructed and can be made by most farmers with the available farm labor.

For horizontal silos 8 ft deep, the concrete needed for wall construction varies from approximately 7 cu ft per ton of silage storage capacity for a silo 8 ft wide to only 4 cu ft per ton for a silo 20 ft wide. A silo 8 ft deep and of average width (12 ft) requires $\frac{1}{5}$ cu yd of concrete per ton of silage storage capacity for the walls. In addition to this there is the $\frac{1}{10}$ cu yd for the floors. From these observations and a number of calculations, it appears that $\frac{3}{10}$ cu yd of concrete per ton of silage capacity is a close estimate for the concrete requirements of a horizontal silo of average dimensions.

The most complete cost data were obtained for a concrete trench silo 102 ft long. The silo is 7 ft deep, 8 ft wide at the bottom and 11 ft wide at the top. The capacity is 6800 cu ft, or 119 tons, figured at 35 lb per cu ft. The silo cost $600 to build during the summer of 1952. This amount includes the cost of digging the trench, depreciation on the form lumber, concrete materials, and considerable hired labor. This is a cost of approximately $5 per ton of silage capacity. With a 4-in floor and 6-in walls, approximately 40 cu yd of concrete are required.

The above-ground horizontal silo shown in Fig. 1 was constructed very economically by a farmer in southern Missouri who is particularly adept at stone and concrete work. The mass-type stone retaining walls are 50 ft long, 6 ft high, 3 ft wide at the bottom, and taper to a little less than one foot wide at the top. The concrete floor is 4 in thick. The materials for this silo, which has a capacity of about 100 tons, cost less than $300.

The above-ground silo illustrated in Fig. 3 is 90 ft long, 16 ft wide, and only 3½ ft high. For economical storage space and minimum spoilage the silo walls should be at least 6 ft high. As may be noted from Figs. 3 and 4, the top profile of the silage surface was left rounded up after packing. The low walls furnished very little protection to the silage over what might be obtained in a stack. This type of above-ground silo with walls and pilasters poured in place is a type of construction, however, that can be used in any location convenient for self-feeding or for silage handling.

Figs. 5 and 7 show two concrete-lined silos, which due to the ground slopes, were constructed partly above and partly below the ground surface. The walls were formed

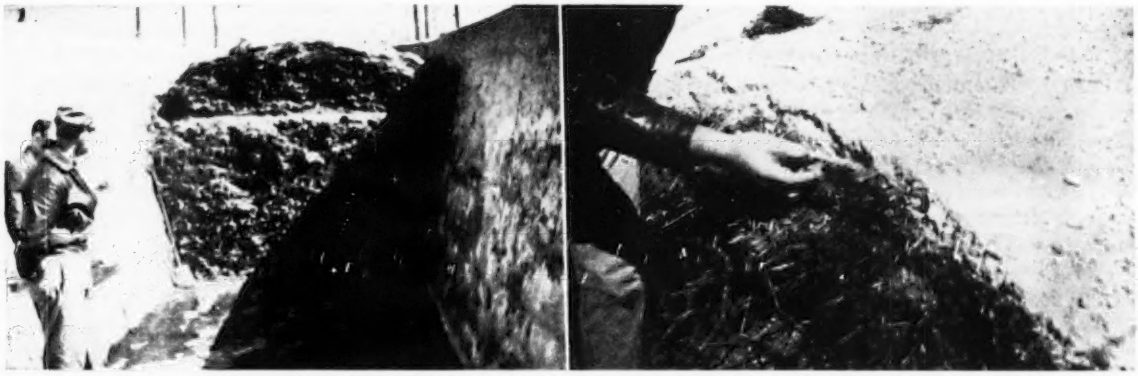

Fig. 5 *(Left)* A concrete floored and lined horizontal silo, 97 ft x 9 ft x 8-12 ft, with a capacity of 9200 cu ft or 160 tons of silage. Cost of digging and materials was $325. Note rounded surface of silage which promotes spoilage along edges • Fig. 6 *(Right)* The limestone protective material as placed over a sisalkraft paper on the silo shown in Fig. 5. Some spoilage is in evidence below the paper. The steep side slope of surface allowed the covering to slip and break the air seal

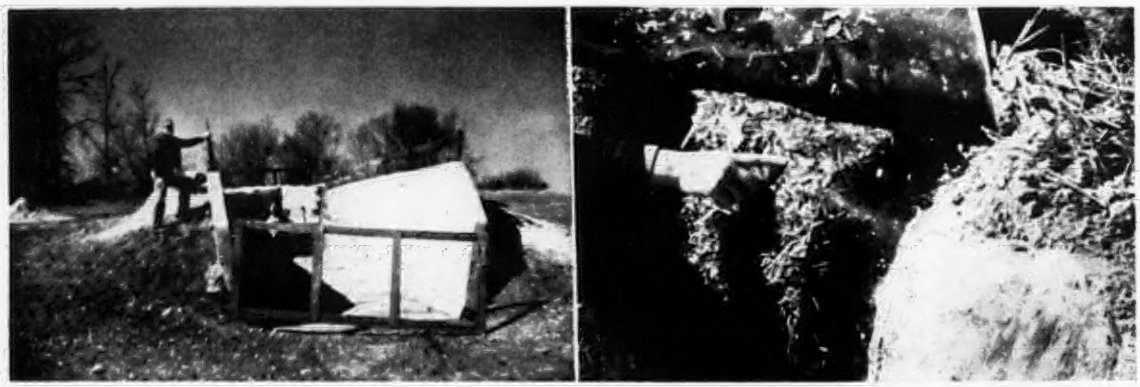

Fig. 7 *(Left)* A combination above and below ground concrete silo, 88 ft x 8 ft x 10-12 ft, with a capacity of 7250 cu ft or 127 tons of silage. The silo cost approximately $300. Note fence posts set in top of walls and the extra sideboards for filling • Fig. 8 *(Right)* This is the protective covering on the silo shown in Fig. 7. Felt (15 lb) under 1½ in of agricultural limestone was used. No spoilage was in evidence. The surface was well packed and kept level rather than rounded up

and poured in place with reusable forms. The silo shown in Fig. 5 has a capacity of 160 tons and cost $325 for digging and for materials. Two-inch steel pipes were set in the top of the sidewalls, in which steel fence posts can be set. The posts can be part of a protective fence, or they can support planks or sideboards to enable overfilling to allow for silage settling. The silo shown in Fig. 7 has a capacity of 127 tons and was constructed for $300. This cost included everything except the farmer's own labor.

Construction Techniques. All of the monolithic concrete silos observed were formed in place. The only one of these that was completely above ground was the one shown in Fig. 3. It therefore was the only one having pilasters to strengthen the walls against filling and silage pressures. Forming the walls is labor consuming and somewhat expensive. This expense could be reduced with re-usable forms where more than one silo is to be constructed in a community. Small contractors could also use this method of construction.

Tiltup construction lends itself to this type of concrete work. The floor should first be placed. It can then be used for casting the wall panels in horizontal sections. After curing, the wall sections can then be tilted into position for the above-ground type. The above-ground silo walls would then necessarily be braced permanently with poured-in-place pilasters at each panel joint.

PROTECTIVE COVERINGS

There was little correlation between the types of protective covers observed in use and the amounts of spoilage. A comparison of the effectiveness of protective coverings is complicated by other variables which have more influence on the amount of spoilage than the coverings themselves. Two of these variables are original moisture content and the packing operation. The lack of proper packing was clearly illustrated in two silos which were so narrow that the center of the silage could not be packed with the rear wheels of the packing tractors. A definitely darker color was in evidence down through this center line. In many of the silos where excessive amounts of spoilage were observed (10 in or more) the farmers reported that the silage was rather dry when it was put in the silo.

Many types of covering materials were observed. Earth was found to be objectionable by most farmers because it freezes and is hard to remove and is undesirable when mixed with the silage. Most farmers, however, used excessively thick layers (up to 6 and 8 in). A 2-in layer is not so undesirable. Sawdust in 6 to 8-in layers was used in many cases, and was quite effective and is easily removed. Agricultural limestone was also found to be in common use. It is easily removed and farmers do not object to some mixing with the silage. The limestone incurs little actual expense since the waste is spread on the fields as fertilizer afterwards.

Regular roofing felt (15-lb) and other waterproof building papers appear to reduce spoilage, although they reduce spoilage very little if the silage is not ensiled at the proper moisture content and packed properly. In some cases where paper was used under adverse conditions it merely deteriorated and 6 to 10 in of spoilage was in evidence. In at least one other instance where 15-lb felt and building paper were used, presumably under more ideal conditions, absolutely no spoilage resulted (Figs. 7 and 8).

Figs. 5 and 6 are of a silo that was packed too high in the center. As the silage settled the covering along the sides slipped and broke the protective seal, causing considerable spoilage. The covering consisted of building paper covered with limestone. The paper had been attacked by the silage acids, and some spoilage was in evidence all over the top surface.

The silage in Figs. 7 and 8 was kept level while being placed and packed in the silo. The silo was also filled above the concrete walls about two feet so that after settling the silage surface was level with the sidewalls. The covering over part of the silage was waterproof building paper covered with limestone, and over the other part (Fig. 8) it was 15-lb felt and limestone. In this case no deterioration of the paper or felt took place and the silage kept perfectly.

The difference in the amount of spoilage in these two silos emphasizes the importance of proper moisture content and adequate packing.

FEEDING METHODS

General. The majority of farmers hauled the silage from the silo to the feeding bunks in wagons or trucks. The silage was therefore handled twice, once when it was loaded and again when it was put into the feed bunks, thus requir-

ing a great deal of time and labor. Few farmers used the tractor and manure scoop for removing the silage and putting it in the bunks. The chief objection to this method is that quite a wide layer is removed, and by the time the entire layer is fed, the top portion of the next layer has begun to spoil. Farmers also object to the uneven, ragged face left on the unfed silage. This method could become popular if a scoop were designed to overcome these objections.

Portable feed bunks are being used and have eliminated one handling operation. The bunk is backed into the silo and filled and then parked in the feedlot. In most cases, however, the farmers using this method do not reduce their labor as much as might be expected, because they use the portable bunk as a hauling device and pitch part of the load into stationary bunks.

In no instance in this study was a farmer found using an elevator or conveying device for loading or unloading the silage at feeding time. Some farmers would doubtless have been forced to this method had there been a wet winter making the earth floors very muddy.

Self-Feeding. Interviews with farmers resulted in the accumulation of the following reasons why so many of them are not self-feeding silage:

1 There is a popular belief that as much feeding space must be provided as has always been used when feeding in bunks.

2 "Boss" cows will guard the feeding area and keep timid cows from eating.

3 It is just as easy to haul silage out of the silo as it is to haul the manure which is wetter and heavier.

4 Cattle will not eat the recommended amount of hay if they have free access to silage.

5 It is impossible to ration the silage when it is self-fed.

6 Silos without concrete floors will become muddy and almost impassible if the cows can run in them.

Farmers who are self-feeding silage are of the opinion that none of these objections, with the exception of the last, have a great deal of validity.

One concrete trench silo (7 ft deep, 8 ft wide at the bottom and 11 ft wide at the top) was observed, in which 27 head of cattle, including 10 yearlings, were fed from four openings in the movable feed gate. The young stock had no trouble with older cows and often ate side by side with them. The manure was scraped out into the lot every third or fourth day, an operation that took about ten minutes.

Figs. 1 and 2 show a silo where 45 dairy cattle were fed with a feeding gate 20 ft long. The cattle worked out a feeding rotation and timid cows and young stock ate their fill by awaiting their turn. The manure had been cleaned out only once during the winter and caused little trouble.

Figs. 3 and 4 show a silo where 33 steers were fed with a feeding gate 16 ft long with eleven openings. The steers had no "bosses" and all fed without trouble. Manure was cleaned from the silo every two weeks.

One farmer, who was using self-feeding, reported that a few timid cows had never been seen in the silo. This herd had many cows with horns, which is believed to be the reason for this trouble. The farmer planned to continue self-feeding, but was having his cattle dehorned. He was feeding 22 cattle in a silo 18 ft wide with 12 openings in the gate.

These farmers have proven that the first three objections to self-feeding mentioned above are without foundation. As many as three cows are being fed for each foot of feeding space. The problem of "boss" cattle has been overemphasized, and has been found to be negligible. The labor to remove manure is but a fraction to the labor required to feed the silage, and most farmers have manure scoops which eliminate hand labor.

None of the farmers had tried to ration the silage, but all were of the opinion that it could be done. If the feed gate is moved ahead at the rate the silage must be fed to last through winter, rationing is automatically accomplished.

It is true that cattle will eat little hay (particularly poor quality hay) if they have free access to good silage. However, many farmers have decided that silage alone is an adequate feed. Many reported increased milk yields, while feeding only silage, over previous years when hay and silage were both fed. In general, observations indicate that free choice of both hay and silage might be desirable so the animals can balance their own feed.

The objection to an earth floor for self-feeding is certainly a valid one, and no one would recommend self-feeding except on a hard-surface floor.

The feeding gates observed vary in construction, as is evident from the pictures, but one feature is important. The bottom foot or eighteen inches must be solid. The cows will pull fresh silage from the pile as long as it is within reach. The silage that falls will not be eaten until last, and the gate must hold it until the cows are forced to eat it. The gate must be anchored in place to force the cattle to eat the portion on the floor and then moved ahead as deemed desirable by the operator.

SUMMARY

It is evident from this study that horizontal silos and self-feeding have many possibilities for increasing the efficiency and economy of chore operations in and around the farmstead. Construction of horizontal silos increased considerably during 1952 and interest in this type of construction is widespread.

Where horizontal silos are contemplated for continued use, concrete floors and sidewalls are recommended. It is estimated that for standard construction, 3/10 cu yd of concrete is required per ton of silage storage capacity. It is assumed that a standard horizontal silo would be one approximately 12 ft wide and 8 ft deep. If self-feeding is contemplated for a good size herd, it will be desirable to make the silo wider and possibly only 6 ft deep. A depth less than 6 ft is not recommended. It is recommended that the top width of silo be 2 to 4 ft more than the bottom width. The silage should be packed level for a height of about 2 ft above the sides of the silo.

Re-usable forms may be used for pouring the sidewalls. Tiltup construction is adaptable to this type of construction and would eliminate the necessity of vertical form work.

Sufficient moisture content and adequate tractor packing is the key to good silage preservation. Under the best conditions approximately 6 in of spoilage will result on the top surface if no covering is used. Earth, agricultural limestone, or sawdust will reduce spoilage. A 15-lb felt or building paper used with a layer of granular *(Continued on page 630)*

The Reclamation of Flooded Lands in Kansas

Walter E. Selby

A FLOOD is a natural event. Flood damage is to a certain extent man-made. Before man moved into the flood plains, the damage resulting from floods was relatively small. Man should never loose sight of the fact that the flood plain belongs to the stream. It is the right of way of the stream and at times in the past the entire flood plain from bluff to bluff has been used. Just because it has not been used for 50 to 100 years is no reason to believe that it may not be used completely at some future time.

This does not presuppose that the flood plains should not be used for agricultural purposes. However, man should recognize the relationship of the stream and the flood plain in his use of the stream valley. If this is done the damage resulting from flooding will be lessened. After any great flood it can easily be seen that permanent structures, farmsteads, farm machinery, etc., aggravate both types of damage, scouring and deposition.

The great flood of 1951 in eastern Kansas was preceded by other great floods. In the Kansas River valley there have been two disastrous floods within the lifetime of many present residents. These were the 1903 and the 1935 floods. The crests of these were not as high as that of the 1951 flood.

The 1951 flood in eastern Kansas climaxed a prolonged wet spring and early summer. Runoff during May and June was above normal throughout eastern Kansas and serious flooding occurred at many points. When the unusually great rainfall of July 9 to12 fell on the area most of it ran off into the already heavily burdened stream channels, creating a flood of a magnitude, believed to be practically unattainable in this area.

The severe storm that caused the great July 1951 flood in Kansas began on July 9 and 10 and generally lasted four days. Intense flooding occurred in the valley of the Kansas River and a number of its tributary streams, in the Marais de Cygnes River valley, and in the Neosho River valley. There were approximately 2,817,616 acres damaged by flood. This included 599,240 acres of non-cropland and 2,218,376 acres of cropland. Of the above figure, 541,269 acres were physically damaged by flood water. It is estimated that 66,000 acres of farm land were rendered unfit for agricultural purposes.

There was extensive damage to agricultural levees and dikes. The Corps of Engineers assumed the responsibility of repairing or replacing these where their existence could be determined either by remaining portions of dikes or levees or by the plans and specifications on file with the state division of water resources. The emergency levee repair program conducted in the Kansas River basin consisted of the placement of 3,584,000 cu yds of earth fill in the restoration of 187 farm levee units. This program was initiated in September 1951 and completed in April 1952. Fifty-five units were restored along the Kansas River (2,620,000 cu yds of earth fill); 53 units along the Republican River (328,000 cu yds of earth fill); and 79 units along the Smoky Hill, Saline, and Solomon Rivers (636,000 cu yds of earth fill).

The mouths of most of the tributary streams that crossed the flood plains of the Kansas River were clogged with silt, sand, and debris. The channels in the lower reaches of many of these streams were clogged or reduced in size by debris and by the sloughing in of the banks softened by the continued flooding.

The Soil Conservation Service under its emergency flood control program in Kansas has assumed the responsibility for channel clearing of the tributary streams, repair and reconstruction of drainage facilities involving more than one farm, construction of barriers, emergency stream bank protection, and channel stabilization structures.

Cleaning debris and sediment from stream channels and from locations above bridges, where necessary to restore channel capacity to that existing before the flood, was done. One hundred nineteen contracts were awarded covering approximately 665 miles of streams.

Cleaning and repairing or replacing minor drainage ditches and outlets which serve more than one farm is being accomplished as rapidly as possible. Seventy-five contracts were awarded covering approximately 65 miles of drainage ditches.

In order to return stream flow to original channels through agricultural lands it was necessary to construct a number of barriers. One hundred thirty-five contracts, covering approximately 320,584 cu yds of earthmoving, were awarded. These barriers vary in length from 200 to 1500 ft.

Some emergency stream bank protection was placed where necessary to prevent imminent changes in stream courses.

Some channel stabilization structures were constructed where necessary to prevent the rapid headward movement of major gullies or valley trenches formed during the flood. Four contracts were awarded for drainage outlet structures. These were large tubes or pipes supported by piling or other means so that the water was emptied into the bed of the stream.

The flood left debris scattered at random over many of the productive acres of the river flood plains. Natural and established farm drainage ditches were filled with debris and silt, sand, or gravel.

Much damage from soil erosion was caused by strong currents flowing against stream banks or across cultivated fields. Potholes of varying size were formed in many areas where strong currents flowed across sandy ridges, dikes, and highways or railroad grades or around trees, buildings, or farm machinery.

Deposits of gravels, sands, and silts seriously reduced the immediate and potential productivity of many of the good farms in the valley of the Kansas River. These alluvium deposits varied in thickness from a few inches to several feet and in many areas contained more sand and gravel, and less silts and clays than the underlying soils. The organic matter in most deposits varied from *(Continued on page 626)*

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Kansas City, Mo., June, 1952, as a contribution of the Soil and Water Division. Accomplishment figures are revised to October 1, 1952.

The author—WALTER E. SELBY—is extension agricultural engineer, Kansas State College.

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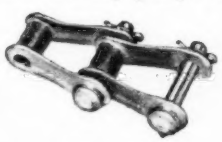

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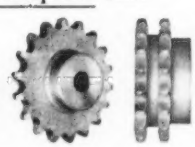

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Reclamation of Flooded Lands

(Continued from page 624)

0 to ½ percent. All deposits are calcareous; the valley was abundantly limed. Available phosphorus is low to very low in sands and gravels and medium to high in the silt deposits. Sufficient potash is available in all deposits, except coarse gravels, for present cropping needs.

Through the cooperative effort of the Extension Service, Soil Conservation Service, the Production and Marketing Administration, Farm and Home Administration, and the landowners and operators in the valleys, the reclamation of the crop acres has progressed rapidly.

Debris removal was one of the first jobs to be done in many valley acres. Debris which consisted of trees, driftwood, wreckage of buildings, damaged equipment, etc., was disposed of in a number of ways. Some of the debris was dozed into piles and burned. Some was placed in gullies, channels, or gouged-out areas and covered during bank sloping and land-leveling operations. Some debris was used for temporary stream bank protection and the protection of the side slopes of barriers. Approximately 24,500 acres were improved by this practice.

It was necessary to drain some areas before other work could be done. Blasting powder or draglines were the most effective methods of doing this work.

Cleaning out, repairing or replacing of permanent farm drainage systems was one of the common needs in all of the flood-damaged valleys in Kansas. Approximately 394 miles of permanent farm drainage ditches have been treated.

There were two general types of soil damage resulting from the 1951 flood, removal and deposition.

There was considerable variation in damage by removal. This damage occurred in greater or lesser degree in most of the river valleys in eastern Kansas. Some were swept off uniformly, requiring only tillage and possibly fertilizer to get it back into production. In other areas the action of the water left vertical banks, gullies, or gouged holes requiring treatment before tillage practices could be accomplished.

The damage to areas resulting from deposition were of three general kinds: (1) silt deposits, (2) intermediate deposits, mixture of fine sands and silt, and (3) coarse sands and gravels. The major portion of deposition damage occurred in the Kansas River valley. Soil Conservation Service personnel mapped most of the area to be reclaimed, determining the kind of material deposited, the thickness of the deposit and the kind and thickness of old or underlying deposits. This information together with results of soil analyses helped to determine the reclamation practices to be applied, and the fertilizer and cropping practices needed.

Land leveling was necessary on land damaged by erosion and also on some of the lands damaged by deposits. Bank sloping, filling, and land leveling in areas damaged by scouring, gullying, potholes or gouging were necessary to eliminate vertical banks and fill and level areas so that normal farming operations could be resumed.

The silt deposits usually occurred in areas by shallow, relatively still water and usually required only good tillage practices to put the area back into production.

In areas where the alluvial deposits were predominately coarse sands and gravels, the reclamation problem was more complicated. The depth of the deposit had to be determined as well as the thickness and texture of underlying material before methods of treatment could be initiated. Where the deposit of coarse materials was 4 in or less in thickness overlying finer materials, ordinary farm plows capable of plowing deep enough to cover the sand with at least 4 in of top soil were used.

(Top) This 36-in moldboard plow is one of the smaller plows used in reclamation work in the Kansas River valley; 42 and 48-in plows were also used • *(Center)* This view shows the 36-in plow at work in one of the flood-damaged fields in the valley. Because of the loose sand and the saturated condition of the underlying soil, it was often necessary to use two or three tractors to pull these plows • *(Bottom)* This view shows one of the fields plowed with the large moldboard plows. This particular field was plowed about 30 in deep. The top layer of sand was plowed under and covered with about 12 in of soil containing a good supply of organic matter, clay and silt. Some of the crop residue can be seen on the surface of the plowed ground

Where the deposit of medium and coarse sand or gravel was 4 to 24 in thick over a finer-textured soil, deep plowing was used providing at least 8 in of top soil (high organic content and fine sand or finer textured material) can be placed over the coarser material. In general, deep plowing was done at a depth of 8 in plus the depth of sand, or twice the depth of sand, whichever was the larger.

Some land leveling usually had to be done to spread excessively thick sand deposits and smooth rough areas prior to deep plowing. Large track-type tractors equipped with bulldozers were the most efficient type of equipment for this work. The best method of operation in loose sand or gravel is to start near the edge of the deposit to be spread and move the first blade full to the area to be filled. Then the tractor is shifted into reverse *(Continued on page 628)*

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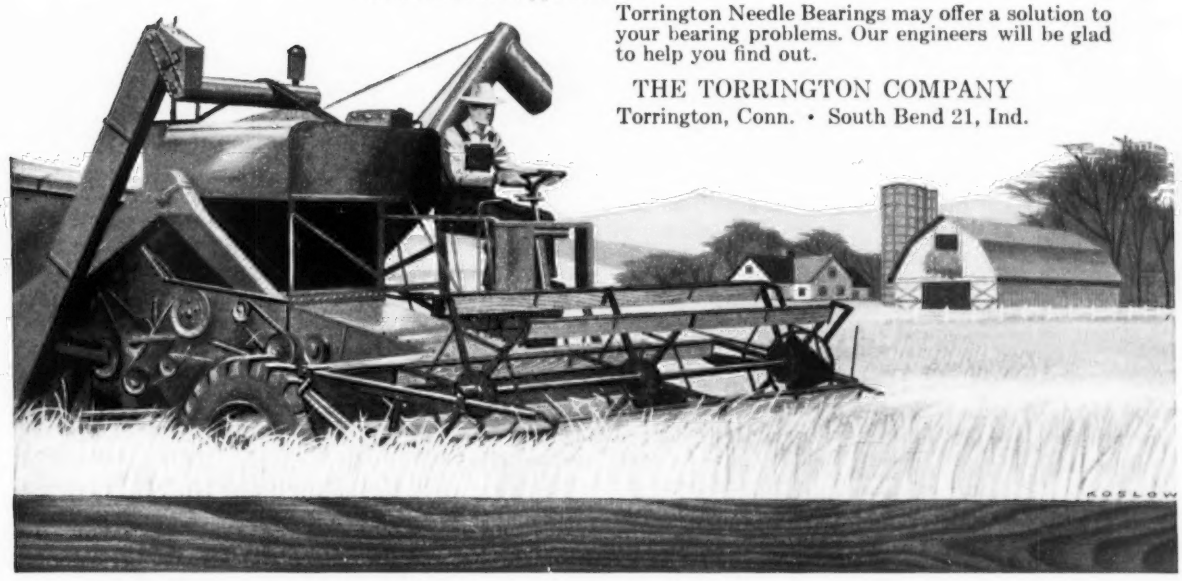

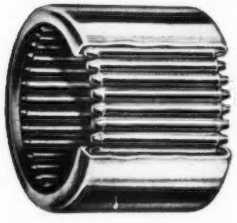

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Reclamation of Flooded Lands

(Continued from page 626)

gear and moved backward until it is in position to move another bladeful of coarse material over the same route. This procedure forms a ridge of loose sand at either end of the dozer blade forming a trough through which the dozer moves the loose material. When this first portion of the deposit is removed the dozer is moved to the right or left and the operation repeated until the leveling or spreading job is completed.

Both moldboard and disk-type deep plows were tried. However, for the conditions in the Kansas River valley the moldboard plow produced the better results.

Some of the early units used in the valley were cable controlled. The hydraulic-controlled plows provide for better depth control. Three sizes of moldboard plows were used — 2-ft, 3-ft, and 4-ft plows.

The 2-ft. plow required one D7 tractor or equal. The 3-ft plow required two D7 tractors or equal. One TD-24 operated a 3-ft plow in a satisfactory manner. The 4-ft plow usually required two D8's or three D7's or equal.

To a certain extent the texture of the underlying soil governs the depth of plowing. For instance, a 12-in deposit of coarse sand will require only 8 in of heavy-textured clay soils to secure a favorable ratio of sand to clay. While 24 in of light textured soil (finer than fine sand) will be required to secure the desired results. (See table 1.)

The surface soil after deep plowing is directly affected by the depth to which the plow extends into the old buried surface soil. If the plow extends deeply enough into the buried surface soil, a sufficient amount of the old surface soil or a favorable mixture of sand and old surface soil will be turned on top to furnish a favorable seedbed. Also a layer of old surface soil extends from the new field surface down to the old soil surface providing for capillary movement of ground water. When too much loose sand and gravel is pushed into the furrow ahead of the plow, a gravel or sand layer tends to develop which will make the soil more susceptible to droughty conditions. A certain amount of the loose sand and gravel normally caves off into the furrow, but the use of a small blade or scraper to push more of it into the furrow was discouraged.

When the plow does not reach a sufficient depth into the old soil, an unfavorable surface soil results, sand is left on top, and the band or layer of old surface soil does not extend from the new surface down to the old soil surface, thus developing a sand layer at the bottom of the plowed depth making the field droughty.

Although the recommended depth to plow into clay to furnish a favorable ratio of sand to clay is less than for other soils, it is more difficult to turn the clay on top. It may come out in chunks and rolls and may roll back into the furrow.

Several factors may affect the manner in which the plow turns underlying soil on top, such as looseness of sand and gravel, speed of plowing, frozen ground, and wetness of underlying materials. This affects the nature of the material left on top after plowing even when plowing is to the recommended depth.

Deep plowing leaves the surface of the field heavily ridged. Fields that are to be planted to crops soon should be smoothed, packed, and cross-cultivated so that ordinary farm machinery can be operated on the field and to provide a more uniform surface soil and a better seedbed.

Fields that are to be left for a period of time before crops are to be planted should be left in the ridged condition to reduce the hazard of blowing. The leveling and smoothing should be done just prior to planting.

It is safest to treat an extensive area rather than isolated fields; otherwise the untreated areas may blow over onto the treated area, leaving it in as bad condition as before treatment. Areas, on which the deposits are too deep or the old surface soil is not of the proper texture for deep plowing, should be mulched or fertilized and planted to a quick-growing crop. Crops should be established on flood damaged lands as quickly as possible and should be made to grow as luxuriant as possible.

The average cost of deep plowing varied with the size of the plow. The 2-ft plow cost about $25 per acre, the 3-ft plow about $45 per acre, and the 4-ft plow about $60 per acre. In some cases the cost of plowing was as high as $70 or $80 per acre where a layer of fine silt laid down by earlier lesser floods, prevented proper drainage and additional tractors were required to secure traction for the plowing operation. About 8,500 acres have been deep plowed.

Some photographs of the 1903 flood show sand deposits not too far different than those that occurred during the 1951 flood. Some of these areas which had heavy sand deposits from the 1903 flood were productive crop areas prior to the 1951 flood. Therefore, it should be recognized that even with a heavy deposit of sand, the soil in the flood plain is not permanently destroyed. Some deposits of coarse sands and gravels from the 1935 flood in the Republican River valley still are not producing a profitable crop. However, similar deposits from the 1951 flood in the Kansas River valley on which some land leveling has been done and which have been deep plowed are now growing crops. These crops are not equal to those produced on the same fields prior to the recent flood, (Continued on page 630)

TABLE 1. MINIMUM PLOWING DEPTH IN INCHES

Texture of underlying soil	Depth of sand covering in inches												
	4	6	9	12	15	18	21	24	27	30	33	36	39
Heavy (H)	12	14*	17*	20	24	28	32	36	40	48	56	64	—
Moderately heavy (F)	12	14	17	22	27	32	36	40	48	54	60	—	—
Medium (M)	12	14	18	24	30	36	42	48	54	60	—	—	—
Moderately light (S)	12	14	21	28	35	42	49	60	—	—	—	—	—
Light (L)†	12	18	27	36	45	54	63	—	—	—	—	—	—
Coarse (C)†													

*At least 8 in of old soil must be turned to provide adequate thickness of soil suitable for seedbed and for tillage operations.
†Plowing less than 12 in deep not recommended; nor is plowing recommended where texture of underlying soil is coarser than loamy fine sand.

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Animal-Drawn Equipment in Turkey

Alton G. Levorson

MANY farmers of Turkey do their tillage by repeated use of the wooden plow, seeding by hand and covering the seed by a final use of the plow. Much of the seed is covered too deep, some is left on top of the ground, with the net result that approximately twice as much seed is used as is necessary when using a grain drill.

Recognizing the need for improved tillage and seeding equipment for the small farmers of Turkey, plus the need for development of Turkish industry, the Turkish Ministry of Agriculture has undertaken to make available 10,000 units of cultivating and seeding equipment. Counterpart funds* are used to finance the project.

Five drills were made up as pilot models in November, 1951, by a Turkish firm which formerly produced armaments. These models were accepted as satisfactory by the Ministry of Agriculture. Production of the 10,000 units started with foundry work under way in February, 1952, and assembly of completed units in October, 1952.

The drill is 1¼ meters in width with seven disk-type furrow openers. It has a fluted force feed with covered gear drive. A forecarriage with two small wheels keeps the weight of the drill from the draft animal's neck and also aids in steering. Provision is made in the design for incorporation of a fertilizer box for spreading fertilizer which has shown startling results on most Turkish soil. A yoke of oxen or a team of horses will be used for pulling the drill.

The drill and cultivator, plus a steel plow and spike-tooth harrow will be sold on liberal credit terms. Credit will be supplied by the agricultural bank.

Under the credit arrangement, the farmers will make no down payment when purchasing the equipment. The first payment of 10 percent will be made following the first harvest. The balance of payments of 15 percent and following three payments of 25 percent are due in the succeeding years until payment is made in full. Interest will be at the low rate of 2½ percent.

In addition to the units offered for sale, 200 complete units are to be used for demonstration by the Ministry of Agriculture field workers in provinces of Turkey where the use of this equipment is not now common.

Previous to the present undertaking, this type of equipment, drills and cultivators in particular, were imported from Europe only in small numbers and sold for cash. The present numbers in comparison are seemingly large, but the 10,000 units are still only one in every four of the 40,000 villages of Turkey.

The author — ALTON G. LEVORSON — is agricultural machinery advisor to the Minister of Agriculture, ECA Mission to Turkey.

*Counterpart funds are the local currency equivalent of dollars received as grant aid under the Marshall Plan. These funds are deposited by the local government, to be programmed jointly by the government and United States representatives for worthwhile projects within the recipient country.

Completed Turkish-made animal-drawn grain drills

Horizontal Self-Feeding Silos

(Continued from page 623)

material on top can eliminate all spoilage if applied properly.

Without mechanical equipment silage is handled twice in feeding. Only one handling is required if portable feed bunks are used. A properly designed tractor manure scoop can eliminate hand labor in removing the silage from the silo and placing it in the bunks or carrying device.

Self-feeding from horizontal silos is a system having good possibilities from the standpoint of efficiency and economy. It appears feasible to let the animals balance their own diet as to hay and silage if both are available all the time. Hand-feeding operations can be eliminated entirely without additional expense for mechanical equipment. As little as 10 min per day was reported as being required to feed silage to a herd of 37 cattle with a self-feeding arrangement. This time was spent mainly in moving the feeding rack ahead, and cleaning out the manure with a tractor and scoop or blade.

Reclamation of Flooded Lands

(Continued from page 628)

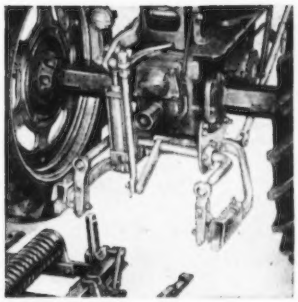
however, they give promise of producing a profit in 1952.

Some vegetable crops have already been marketed from some of the reclaimed areas near Kansas City. Other crops on reclaimed land are producing gratifying yields in spite of a shortage of moisture this season.

It is gratifying to note that the application of engineering skills together with soils and crops information and practices are making it possible to restore much of these flood-damaged valleys to production this year. Of course, it will take a few years to build up the organic matter and balance up the plant nutrients in many of these soils to secure maximum production. However, it is encouraging at a time when productive acres are needed so badly to know that 8,500 acres of this valuable flood plain land is now growing crops as a result of land leveling and deep plowing. In addition several thousand more acres are now growing crops as a result of debris removal, establishment of surface drainage, land leveling and smoothing so that farming operations could be accomplished efficiently.

A report to you about men and machines that help maintain International Harvester leadership

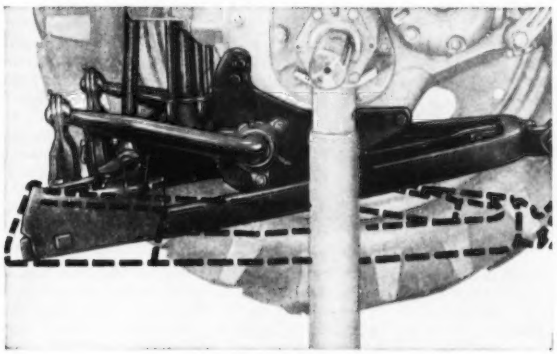
How hydraulic Touch-Control made possible NEW McCormick® Farmall® Fast-Hitch



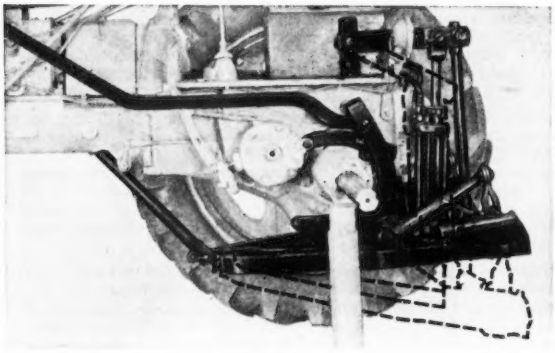
With new Farmall Fast-Hitch, twin coupling beams on the implement engage F-H sockets as the tractor is backed, locking *automatically, instantly, precisely.* Aligning the sockets to meet the coupling beams is done hydraulically, utilizing any or all of *three* independent movements of Fast-Hitch made possible only by Farmall Touch-Control and shown in the accompanying illustrations.

Farmall Fast-Hitch and Touch-Control with three double-acting cylinders, each independently controlled, enable the tractor operator to use hydraulic power these *11 ways:*

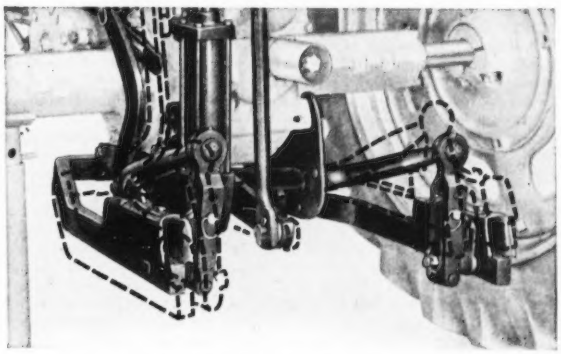
- **Line up Fast-Hitch sockets accurately for coupling implements.**
- **Power-lower each implement to its work with needle-point accuracy.**
- **Tilt or level plows.**
- **Control height of draft point of plows and other implements.**
- **Control trailing implements from the tractor seat.**
- **Control front and rear-mounted implements together or separately.**
- **Control right and left gangs of front-mounted cultivators together or separately.**
- **Apply down-pressure to front-mounted cultivator gangs.**
- **Jack up tractor for changing rear wheel treads.**
- **Lower the drawbar for no-lift hitching to trailing implements.**
- **Adjust drawbar height for the best hitch to trailing equipment.**



1. Raise and lower draft point hydraulically, to align drawbar yoke and Fast-Hitch sockets with implement coupling beams. When plowing, raise or lower the draft point throughout the range illustrated above. Lower the draft point for deeper plowing, raise it for shallower work. The forward draft point gives a true line of draft which maintains selected plowing depth.



2. Raise and lower Fast-Hitch sockets hydraulically to the height of the implement coupling beams. The slip-on drawbar for trailing implements may be lowered for no-lift hitching.



3. Tilt and level hydraulically, both for instant alignment of Fast-Hitch sockets for automatic coupling, and for tilting plows to open and finish lands. Tilt or level precisely, *on the go!*

IH engineering teamwork produced both hydraulic Farmall Touch-Control and new Farmall Fast-Hitch. IH research, engineering and manufacturing men are constantly pooling their time and talent to solve farm problems—to provide equipment that makes farm work easier and the farmer's time more productive!

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RESEARCH NOTES

Brief news notes and reports on research activities of special agricultural interest are invited for publication under this heading. These may include announcements of new projects, concise progress reports giving new and timely data, etc. Address: Editor, AGRICULTURAL ENGINEERING, St. Joseph, Michigan.

USDA Research Activities

Ginning Laboratory Addition. Wilbur M. Hurst, head of the Division of Mechanical Processing (BPISAE) U.S. Department of Agriculture, Beltsville, Md., reports that the Mesilla Park (N.M.) Roller Ginning Laboratory addition will be ready for use in experimental work during the 1953-54 cotton-ginning season. On a recent inspection trip to the laboratory, Mr. Hurst found the roller gin machinery installed and awaiting only the extension of power lines to get the machines in operation. As a result of these installations, the Laboratory will be able to initiate some of the experimental work which has long been given high priority by the Cotton and Cotton Seed Advisory Committee, and for which Congress last year appropriated special funds.

Engineers Help Sought by BEPQ. The Division of Mechanical Processing, BPISAE, has been requested by the Bureau of Entomology and Plant Quarantine to determine through investigation what machine or operation in the ginning process is responsible for heavy mortality in pink bollworms. The request follows discovery that 50 to 95 percent of these pests in the seed cotton are killed during the ginning process. If killing effect can be traced to a specific machine or operation, it may be possible to modify machines or methods to make the killing power 100 percent effective. Such improvements would eliminate the need for the relatively inefficient process of sterilizing cotton seed and gin waste to prevent spread of this insect pest.

Flax Dryer Ready for Trial. A three-stage flax dryer, designed to dry flax as it comes from the retting tanks, will be ready for trial on the 1953 flax crop under the research program being carried on by the Mechanical Processing Division of BPISAE at Corvallis, Ore. Jesse E. Harmond, agricultural engineer, is in charge of the project. The new machine will eliminate open-field drying methods under which the flax straw is subjected to the effects of weather and is seldom ready to market in less than 18 to 24 months. With the new machine, the fiber can be dried and marketed in much less than one year.

Pink Bollworm Weapon. BPISAE Farm Electrification Division engineers, encouraged by success last year in experiments with fluorescent light traps, believe they now have a new weapon with which to combat the pink bollworm moth. This winged "wetback" from south of the Rio Grande caused damage to the Texas cotton crop estimated at $28,000,000 in 1952. Experimental light traps were operated in the Rio Grande valley near San Benito, Tex., from May 27 through December, 1952. Results proved the so-called "black light," providing near ultraviolet radiation, the most effective. In consequence, additional light traps were placed in operation in 18 different locations in Texas, five in Louisiana, and one in Mississippi. Through the latter experimental use, new infestations were found in two Texas areas previously believed to be uninfested, although no moths were caught in the traps in either Louisiana or Mississippi. Based on the study, however, which is a cooperative project between the Bureau of Plant Industry, Soils, and Agricultural Engineering and the Bureau of Entomology and Plant Quarantine, the light traps have practical value for (1) locating new infestations, (2) migration studies, (3) timing insecticide applications, and (4) determining the intensity of infestation from field to field and from year to year. Although the light traps are not recommended by USDA to farmers as a direct means of control, the experimental work has stimulated widespread interest in Texas and extensive use by large cotton growers is possible in the future.

Ventilation Tunnels. Tests of ventilation tunnels designed for use in grain storage bins under the Commodity Credit Corporation grain storage program, have shown that tunnels of 1½ sq ft cross section made of 16 and 13-gage galvanized steel and approximating an inverted catenary curve in shape are fully capable of withstanding the grain pressures likely to be encountered in farm storage bins. The tests made by Great Lakes Steel Corporation in Detroit in July, in collaboration with the Farm Buildings Division of BPISAE, utilized a small box with a lucite front to house the tunnel specimens which were fitted with a series of dials on the perimeter of the catenary curve to indicate deflection changes as pressures were increased. Grain pressure was simulated by filling the boxes with grain and applying controllable pressure from the top. The lucite front on the box permitted close observation as the tests progressed.

Wind Load Tests. Rafter design for 1½-story barns is being investigated by BPISAE engineers in cooperation with the Forest Products Laboratory at Madison, Wis. Wind load tests are being made on full-scale trussed rafters with the equipment available at the Laboratory. Weak joints in the various designs of rafters will be analyzed and improved as the tests progress. In making these tests, small bags of sand are hung directly from the specimen rafters to represent the dead load from a roof. Suction and pressure from wind are simulated by the use of weights suspended by wires and pulleys from a stiff frame above the test specimen. Horizontal and vertical deflections are automatically recorded on graph paper at the ridge and knee joints, and calibrated load rings measure reactions at the base.

Earthquake-Resistant Construction Tests. Publication of USDA's research work on windload-resistant construction for haymow floors has developed considerable interest in the possibilities of such construction toward making walls and floors of frame buildings earthquake-resistant. The work on haymow floors construction was conducted with the cooperation of the Forest Products Laboratory at Madison, Wis. As a result of this effort, the Laboratory has been asked to test the earthquake-resistant qualities of frame wall and floor construction under a joint project being sponsored by the U.S. Army and the state of California.

Cotton Production Mechanization. Cotton production practices in which the USDA Agricultural Engineering Division has taken part in an effort to adapt production methods to mechanization have resulted in reduced labor costs, increased efficiency of mechanical pickers, and in a substantially reduced trash content in the raw product harvested by the machine. The engineers worked out methods of mechanical topping of cotton plants to determine the effect of this practice in preventing lodging, its effect upon the efficiency of mechanical cotton pickers and upon the yield of cotton. The machine topping was done during the late growing season by attaching a sickle bar of the type normally used in grain harvesting, or a rotary cutter, to high-clearance cotton picker machines or tractors. Results indicated machine topping to be about equal in machine picker efficiency to hand-topped cotton, with an obvious saving in labor. Yields of cotton were not reduced by machine topping unless the machine was set to cut at a low height from the ground. Further, the machine topping experiments indicated the practice to be a deterrent to loading of the cotton plants. Lodging in untopped check fields was serious enough to hamper harvest operations and reduce picker machine efficiency.

Agricultural engineers also helped in the development of machines for the application of defoliants which were used in the California cotton production investigations. The defoliation experiments were made to determine the effect of this practice on picker efficiency and upon grade of mechanically harvested cotton. The use of a regular defoliant gave better results in reducing trash content in harvested cotton than the application of a desiccant (used to shrivel plant tissue).

Loose-Housing Bulletin. Thayer Cleaver and Robert G. Yeck, agricultural engineers of the Division of Farm Buildings, BPISAE, are joint authors of an USDA bulletin, "Loose Housing for Dairy Cattle," which came off the press in July. Copies are available from the Division of Information, U.S. Department of Agriculture, Washington 25, D.C.

FMD Acquires New Plane. The Division of Farm Machinery has recently taken delivery on a Piper Super Cub which will be used in connection with investigations to develop aerial application equipment for insect-pest and plant-disease control work. Frank Irons, agricultural engineer, BPISAE, in charge of this research work at Toledo, Ohio, is expected to come to Beltsville, Md., soon to meet with engineers and entomologists for the purpose of mapping out a work plan in which the new plane will be used.

Nichols Heads Tillage. M. L. Nichols, formerly with the Soil Conservation Service and recently transferred to the Bureau, was appointed in June to head USDA's Tillage Machinery Laboratory at Auburn, Ala., which he helped to develop and establish in 1935. Nichols is a former head of the agricultural engineering department of the Alabama Polytechnic Institute. He succeeds Eugene G. McKibben who left the Auburn post to become director of agricultural engineering research, BPISAE, at Beltsville, Md., in February, 1952. I. F. Reed, who has been acting in charge of the tillage laboratory, will now devote more of his time to the administration of the oil-bearing production machinery project, mainly peanuts and tung.

Liljedahl to Minnesota. Louis A. Liljedahl, assistant agricultural engineer, was appointed July 1, 1953, to take charge of USDA's weed control machinery project at the Minnesota Agricultural Experiment Station, St. Paul. The post has been vacant since Russell Larson, agricultural engineer, left about two years ago to head up engineering phases of USDA's national weed control project at Columbia, Mo. Mr. Liljedahl, a member of ASAE and a native of Iowa, obtained a B.S. degree in Agricultural Engineering at Iowa State College in June, 1950. Until recently he was a corporal in the U.S. Army, having served on active duty in Korea for a part of the two years he spent in the service.

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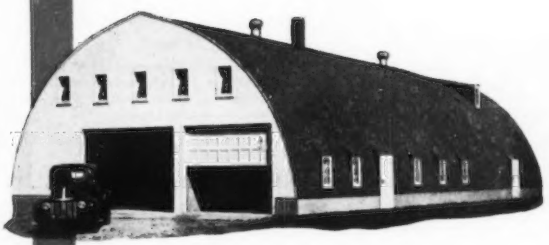

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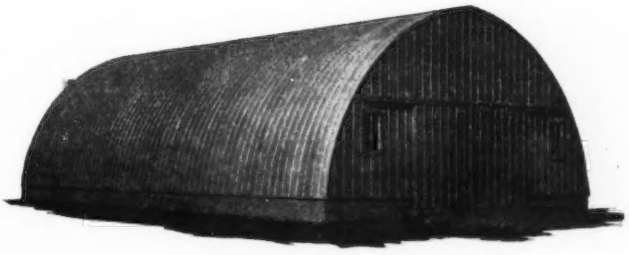

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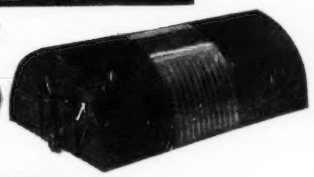

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INSTRUMENT NEWS

KARL NORRIS, Editor

Sponsored by the ASAE Committee on Instrumentation and Controls. Contributions on agricultural applications of instruments and controls and related problems are invited, and should be submitted direct to K. H. Norris, Agricultural Research Center, Beltsville, Md.

Control for Temperature Fluctuation

By I. J. Pflug and R. J. Misiaszek
MEMBER ASAE

INSTRUMENTATION for a relatively simple project — Controlled Temperature Fluctuation of a Low-Temperature Refrigerator can have many pitfalls to overcome before reasonable operating perfection is accomplished with the usual budget limitations.

The usual fluctuating conditions can be created by adjusting the rate of cooling and rate of warmup of the refrigerator between a top and bottom limit. If the project is well financed, a proportional control system can be developed using a cam-operated controller that will duplicate any desired cycle. A less expensive approach to the problem is the use of two thermostats — one set at the high temperature and the other at the low temperature.

The rate of temperature change within the refrigerator will depend on the mass and rate of heat transmission of the refrigerator. A low-heat transmission rate combined with a high refrigerator capacity will result in rapid cooling and slow warmup. The rate of warmup may be increased by opening the door, but this method can result in erroneous findings, because of changes in ambient air conditions and the chance of human error. A large electric heater (1 to 1.5 kw per 100 ft^3) installed in the refrigerator eliminates these problems, and the warmup cycle can be completely controlled by varying the output of the heater. For short warmups the heater operates during the entire warmup period. The rate of cooling can be varied by changing the speed of the compressor.

Frozen food can be seriously damaged in a few hours if the refrigeration system fails and the heater continues to operate. A limit thermostat inserted in the control circuit of the heater provides the necessary protection in case of refrigeration failure.

The timing of the fluctuation cycle must be accurate as well as continuous. The cam-operated controller fulfills this requirement ideally but expensively. In the two-thermostat method, cycling is accomplished by switching from the low to the high-temperature thermostat. This can be performed manually, but for long-term experiments it is not practical. Commercial timers that will perform various cycling operations are available; during the test an Eagle Flexopulse cycling timer provided the necessary versatility and accuracy required in the simulation of actual conditions.

Fenwal thermostats were used in the installation: The temperature controlling thermostats open with a decrease in temperature for refrigeration operation, whereas the safety thermostat opens with an increase in temperature. The control system is fused separately to give the control devices additional protection.

A wiring diagram of the control system is illustrated in Fig. 1.

Data obtained with a Leeds and Northrup potentiometer and 30-gage copper-constantan thermocouples indicated that the time required for the circulating air in the refrigerator to go from −5 F to +10 F was 5 min, with 6 min required to reduce the air temperature from +10 F to −5 F.

This paper is contribution No. 875 of the Massachusetts Agricultural Experiment Station.

The authors — I. J. PFLUG and R. J. MISIASZEK — are, respectively, associate research professor and former member research staff, Massachusetts Agricultural Experiment Station.

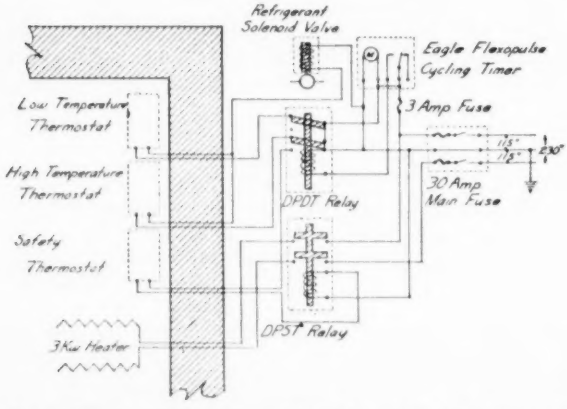

Fig. 1 Control system for automatically fluctuating the temperature of a refrigerator

Development of Engineers

A PROPER plan for the development of engineers (by the management of a company employing them) should include:

1 A plan for their selection.

2 A plan for specialized training and orientation and appropriate evaluation upon first coming to work.

3 A plan for advanced technical education appropriate to the aims and objectives of the company applicable to the first few years of employment.

4 A logical and effective plan of organization involving a minimum of supervisory layers, very few undefined responsibilities, and staffing by men with a clear understanding of their supervisory and management responsibility.

5 A continuous system of properly appraising the contributions of the individual engineer.

6 A strong interest in the engineer and a means for effectively guiding him along either the path of supervision and management or on the path of individual technical attainment.

7 The necessary and appropriate means for assisting the engineer to become more competent in either of the paths described in item 6 beyond that which can be obtained by "on the job" training.

8 A real interest in the engineer and a plan to help him with his participation in professional societies.

9 A plan to interest and stimulate the engineer not only in a field of technical or management attainment but also in the field of economic and political understanding.

—F. K. McCune in *Electrical Engineering* for June, 1953

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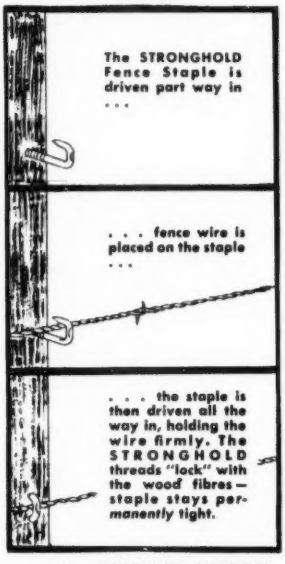
The STRONGHOLD Fence Staple is driven part way in . . .
. . . fence wire is placed on the staple . . .
. . . the staple is then driven all the way in, holding the wire firmly. The STRONGHOLD threads "lock" with the wood fibres – staple stays permanently tight.

WON'T "POP" or loosen, even in creosoted posts. Stronghold threads "lock" with wood fibres—*gain holding power after driving.*

DRIVE FAST Flattened head makes driving easy and fast. Staples go in straight.

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The Stronghold Fence Staple is a new and revolutionary development which entirely outmodes the old-fashioned U-shaped staple. It permits new ease of application—saves manpower—virtually eliminates costly fence maintenance made necessary by staples which loosen and pop out.

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Where ordinary staples lose up to 50 per cent of initial holding power *within as short a period as six weeks*, Stronghold Fence Staples *gain* holding power up to 25 per cent, and this increase continues as time goes on, according to exhaustive tests made by Wood Research Laboratory of Virginia Polytechnic Institute, as reported by Dr. E. George Stern. (Copies of Dr. Stern's findings gladly sent on request.)

The permanent holding power of Stronghold Fence Staples is particularly important in creosoted posts, where "popping" of the ordinary staple is speeded by the tendency of the creosote to act as a lubricant. Stronghold Fence Staples hold tight—*permanently tight*—in creosoted posts!

In addition to other advantages, the design of Stronghold Fence Staples permits one man to do the job of fencing or repair, as is clearly shown by diagrams at left.

Stronghold Fence Staples weigh less—count up to 50% more to the pound. Thus they cost little if any more than ordinary staples, and their permanent holding power, ease of application, and elimination of fence maintenance not only offset any small additional initial cost, but result in large and continuing savings.

Recommended length of longer leg, 1½" or 1¾"—.148 diameter. Furnished in regular steel, plain or hot galvanized. Can be supplied in any other size, in regular or hardened steel, in any finish; or in non-ferrous metals. Write us your problems.

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INSTRUMENT NEWS

KARL NORRIS, Editor

Sponsored by the ASAE Committee on Instrumentation and Controls. Contributions on agricultural applications of instruments and controls and related problems are invited, and should be submitted direct to K. H. Norris, Agricultural Research Center, Beltsville, Md.

Device to Record Hourly Temperatures

Charles N. Hinkle
ASSOC. MEMBER ASAE

HOURLY temperature records instead of continuous records would satisfactorily serve the purpose for many types of experimental work. In order to obtain an hourly temperature record when using a Brown recording potentiometer, some device is required to turn on the chart-drive mechanism at hourly intervals and to turn it off after sufficient time had elapsed to print a series of temperatures. Several circuits were tried, and the following is the one which has proven most satisfactory and is being used at present.

The principle used was that of turning the chart drive on and off while having the instrument power on all the time. For all circuits tried, a synchronous clock with a one-hour switch period was used to turn the chart-drive mechanism on. The switch-setting dial was marked in percent of an hour for which the switch would be closed. It was possible to set this dial only within about 0.5 percent an hour, which would amount to approximately 18 sec. This resulted in a plus or minus accumulating error, making it impossible to identify the printed temperatures with their respective hours. Thus it was necessary to use some other method for shutting off the circuit once it was initiated by the time clock.

To accomplish this purpose a microswitch was mounted on the potentiometer as in Fig. 1. The switch had a flat follower which made contact with a cam mounted on the shaft pointed to by the arrow in Fig. 2. On the eight-point potentiometer two cam rises were necessary since this shaft revolves once every sixteen points. The microswitch was wired in the normally closed position and was opened at the end of a series of readings by the action of the cam against the follower.

To reduce the possibility of stopping the instrument during the standardization cycle, the microswitch should be mounted so that the switching mechanism has switched to number one thermocouple and the recorder has started to balance before the circuit is stopped by the microswitch.

Both the time-clock switch and the microswitch were wired in parallel with the chart-drive switch located on the front of the chassis. The closing of any of these switches would thus start the chart-drive action. A typical circuit sequence for the eight-point potentiometer would then be as follows:

1 The chart-drive switch would be set in the off position.

2 At the hour, the time-clock switch would close starting the chart-drive action.

3 After a short interval of time required for printing approximately two points, the cam for the microswitch would have turned enough to allow the follower to fall thus closing the microswitch.

4 Somewhere during the middle of the series the time-clock switch would open, but the chart-drive action would continue because the microswitch would be closed.

5 At the end of the eight-point series the cam will raise the follower opening the microswitch and thus stop the chart-drive action.

For every following hour, steps 2 to 5 would be repeated. When a separate switching box is used to increase the maximum possible number of temperatures recorded by the potentiometer, the setup would be similar to that above. In the illustrated case any multiple of eight points could be read by leaving the time clock switch closed until the middle of the final set of eight points. If it were ever necessary to run the chart drive continuously, the chart-drive switch on front of the chassis would be turned to the on position and then the other two switches would have no effect.

When other electrical units are to be used in conjunction with the hourly temperature recordings, provisions can be made to turn them on and off every hour by the above arrangement. This might apply to such items as fans used for the air movement across wet-bulb thermocouples. This is done by connecting two wires to terminals B and F on the chassis terminal block. These wires are then brought out to a convenience outlet located outside of the potentiometer. Thus, whenever the chart drive was in motion, there would be 110 v available at this outlet.

Approved as Journal Series Article No. 1472 of the Michigan Agricultural Experiment Station.

The author—CHARLES N. HINKLE—formerly instructor in agricultural engineering, Michigan State College.

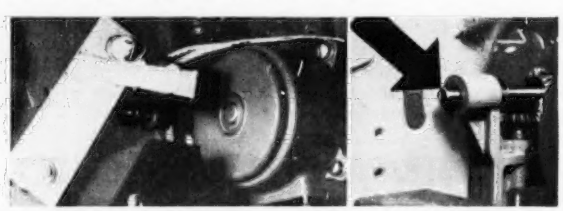


Fig. 1 *(Left)* Microswitch mounted on the recording potentiometer • Fig. 2 *(Right)* Arrow indicates shaft for mounting cam with which a flat follower on the switch makes contact

Philosophy for Engineers

THE University of Detroit has recently announced that "engineering students will be required to complete a sequence of philosophy courses beginning with the pre-senior year in 1953-1954. . . . The sequence will comprise logic, philosophy of life, and moral philosophy."

There can be no question that logic is an appropriate study for engineers. It is defined as "the science that deals with causes and criteria of validity in thought and demonstration," and as such it is basic to the scientific method by means of which engineers analyze their problems, sort out and test facts, and synthesize results into workable knowledge.

The ideologies which have stemmed from the writings of philosophers have so influenced systems of government and individual and public morals as to bring into conflict their basic principles which, to those who hold them, are dearer than life itself. But confusing as the study of the writings of philosophers may be, the scientist and the engineer should, above all people, recognize in them the same continuous revision of hypothesis to fit the known facts that has existed and is taken for granted in their own field of natural philosophy. — From *Mechanical Engineering* for August, 1953.

"....to Wrestle with Mondamin"

THAT'S an Indian name—Mondamin. Ojibway Indian.

Mondamin was a spirit—the spirit who wrestled with Hiawatha on four successive days and over whose grave, after his defeat and burial by the young brave, there grew a wonderful tall, green, long-leaved plant.

That, says the legend, was the origin of corn. And, thereafter, in the Autumn, when the long, green leaves turned yellow and the tribe spoke of harvesting the corn, they spoke of "wrestling with Mondamin."

The legend of Mondamin is one of the many stories—some fact, and some fancy—attending the glorious history of corn.

And today, with the new No. 227 Corn Picker, John Deere writes another great chapter to that history. For this big-capacity, two-row mounted picker—the result of many years of intensive engineering, experimentation and field testing—supplies the muscle, the stamina, the speed, and championship performance demanded "when the long, green leaves turn yellow"—when, season after season, the time rolls around "to wrestle with Mondamin."

In lengthy and extensive field tests, the new John Deere No. 227 has worked around in corn from the Rio Grande Valley of Texas through the Corn Belt and on up into the corn-producing northern states. It has won its spurs in dry, brittle corn . . . in tough, heavy crops and in light yields . . . in corn-borer-infested crops . . . in soft, wet, snow-covered fields . . . and in badly down-and-tangled crops. It's a young, tough, seasoned campaigner, ready, willing, and able to handle the harvests in the years ahead.

JOHN DEERE • MOLINE, ILL.

QUALITY FARM EQUIPMENT SINCE 1837

"Measuring the Forces in Tractor Linkage"

TO THE EDITOR:

THE article, entitled "Measuring the Forces in Tractor Linkage," by Rogers and Johnston, published in AGRICULTURAL ENGINEERING for August, contains interesting information. It corroborates material from other sources.

However, the equation at the top of the second column on page 543 is an illustration of a practice which frequently leads to error. It omits the largest force acting on the tractor, namely, the pull of gravity or the tractor's weight. This is a risky procedure and one which is likely to lead to a wrong conclusion.

The 458 lb is not the entire increase in rear-wheel loading. Neither is it the load removed from the front wheels. For these reasons it is misleading to call it weight transfer. This term is used commonly for the reduction in front-wheel loading, that is, the reduction in R_2 due to drawbar or link forces and the overcoming of rolling resistance. About all that can be said of the 458 lb is that it is the rear-wheel loading of an imaginary tractor pulling the same load but having no weight, or one with all weight balanced over the front wheels.

It is noted that the authors add another item to arrive at R_1. This other item is due to the fact that R_1 is ahead of the axle. The better method is the straight-forward one of making a moment equation which includes all external forces. If, as the authors did, we take moments about Q (see accompanying sketch), the complete equation becomes

$$R_1 = (3100 \times 50 + 2500 \times 20 - 1220 \times 34.9 + 200 \times 85.9 + 107 \times 87.6)/74 = 2558$$

This is the same value of R_1 but is reached by a direct instead of by a devious method.

We are now ready to get the reduction of loading of the front wheels which is usually called weight transfer. We equate the vertical forces and find that R_2 is approximately 850 lb. This subtracted from the static loading, gives 210 lb removed from the front wheels.

This analysis can be carried farther by finding the resultant of the link forces. This is the resultant pull between the plow and the tractor, which I have labeled PV. Its line of action is sometimes called "line of draft." "Line of pull" is a better term for it, because some prefer to limit the word draft to the directional component of the pull. Since the links in this case are free links, PV passes through their intersection. PV has a value of 1350 lb and a lever arm about point C of practically 8½ in. Taking moments about C,

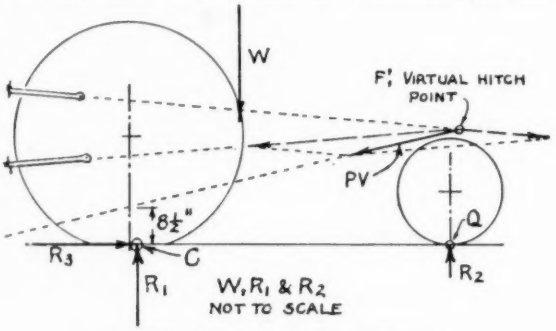
$$R_2 = (3100 \times 24 - 1350 \times 8.5)/74 = 850 \text{ lb (rounded)}$$

This, as it should be, is the same as given above.

While the error in this case is mainly a misunderstanding about the weight transfer, the practice of omitting important forces is always dangerous, and is likely to lead to wrong conclusions. For example, an article published last year attempted to draw conclusions about tractor wheel loading without including the following:

1 The weight of the implement
2 The soil force on the implement's working face
3 Support, if any, furnished to the implement by wheels or sliding surfaces.

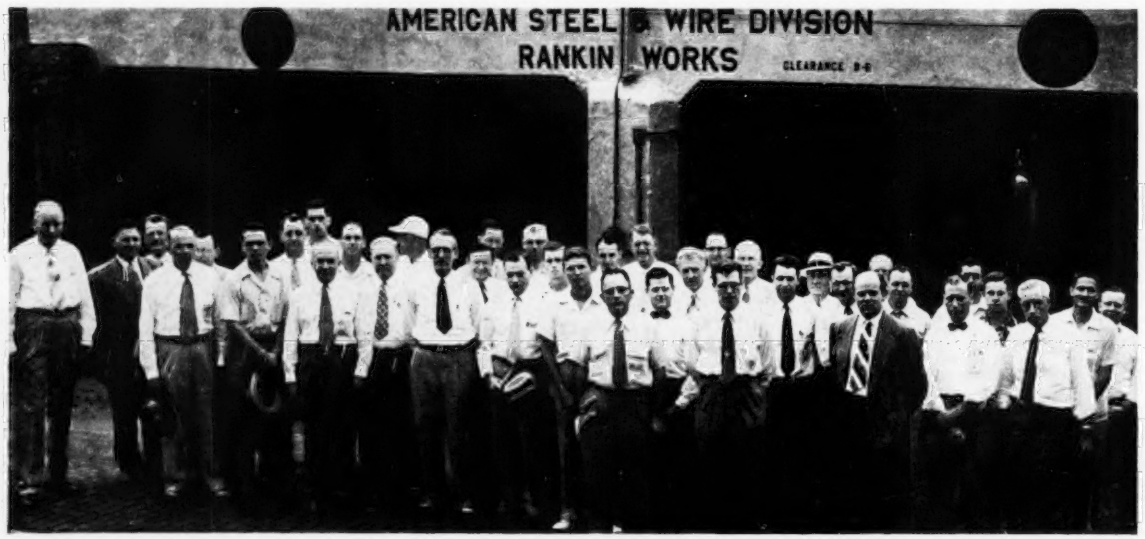
The result was a wrong conclusion about mounted implements.



Sketch showing forces acting on tractor

The practice of omitting important forces violates the first principle of mechanics, that of equilibrium of forces and moments. The safe method is simple. It is merely to consider the tractor or implement as a free body, put in all important external forces, including weight, and then determine what value any unknown force must have to give equilibrium. This is not difficult if the object is at rest or is moving at uniform velocity. In case the object is accelerating or decelerating the procedure is the same, except that we must include the inertia force acting at the center of gravity of the object.

A. W. CLYDE
Professor of agricultural engineering, Pennsylvania State College



Group of members and guests attending the 1953 annual meeting of the American Society of Agricultural Engineers, on a visit to the Rankin Works, American Steel & Wire Division, U.S. Steel Corporation, in Pittsburgh

the chilled-iron face gives Eaton Tappets superior load-carrying capacity and longer life

To meet the exacting requirements of today's farm tractor engines, Eaton has developed special foundry facilities to produce chilled-face tappets with essential hardness and wear-resistant characteristics. Eaton offers volume-produced, volume-priced tappets capable of carrying excessively high loads.

From the ladle to final inspection, the wear-resistant hardness of the face and the over-all quality of Eaton tappets are guarded by precise metallurgical control.

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PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

NEWS SECTION

ASAE Winter Meeting

THE regular winter meeting of the American Society of Agricultural Engineers, held each year in Chicago, will be held this year on Monday, Tuesday, and Wednesday, December 7, 8, and 9, at the Edgewater Beach Hotel. Members of the Society and other interested persons will shortly receive copies of the official reservation forms for arranging hotel accommodations, and since most of the hotel's guest rooms have been reserved for those attending this particular meeting, guest room reservations for the period of the meeting will be honored only when received on the official forms to be distributed by the Society.

The meeting is being held one week earlier than usual this year to avoid close proximity of the meeting dates to the Christmas holidays which heretofore has been objectionable to many, especially those who travel long distances to attend. The 1952 meeting registered an attendance in excess of 1100, and it is anticipated that the attendance at the meeting this year will exceed that number.

The main feature of the meeting, as usual, will be the technical programs arranged by four of the Society's divisions — Power and Machinery, Soil and Water, Farm Structures, and Rural Electrification. These programs are now in practically final form and a brief review of them will be released in the October issue of AGRICULTURAL ENGINEERING.

Dykes New Chairman ASAE Washington Section

J. C. DYKES, deputy chief, Soil Conservation Service, U.S. Department of Agriculture, was elected chairman of the Washington (D. C.) Section of the American Society of Agricultural Engineers at a meeting of the Section held June 12. He succeeds W. R. Noble, Washington manager of the National Retail Farm Equipment Association. Other officers elected included G. C. Winter, former Washington representative of the Farm Equipment Institute, as the new vice-chairman, and Hajime Ota, agricultural engineer, farm buildings and housing division (BPISAE), U.S. Department of Agriculture, who was elected the new secretary-treasurer of the Section.

The guest speaker at the meeting was Lawrence H. Skromme, a vice-president of ASAE and chief engineer of the New Holland Machine Division of The Sperry Corporation.

ASAE Meetings Calendar

September 25 and 26—ALABAMA SECTION, Gulf Shores.

October 10 — OHIO SECTION, Ives Hall, Ohio State University, Columbus.

October 24—MICHIGAN SECTION, Detroit.

December 7-9 — WINTER MEETING, Edgewater Beach Hotel, Chicago, Ill.

February 1-3—SOUTHEAST and SOUTHWEST SECTIONS, Dallas, Tex.

April 2 and 3 — ROCKY MOUNTAIN SECTION, Colorado A. and M. College, Fort Collins.

June 20-23—47TH ANNUAL MEETING, University of Minnesota, Minneapolis.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

Michigan Section October Meeting

A MEETING of the Michigan Section of the American Society of Agricultural Engineers is to be held Saturday, October 24, in the Detroit area. The place has not yet been announced.

Four technical papers are to be featured on the program, as follows: "High Speed Mower Design," by Lee Elfes, Harry Ferguson, Inc.; "Field Results with Prefabricated Drying Buildings," by David B. Poor, Great Lakes Steel Corp.; "Equipment Used in Bulk Milk Handling," by Carl W. Hall, Michigan State College; and "Trends in Forage Handling and Storage," by Robert G. White, Michigan State College.

Further information on the meeting will be released to Michigan Section members and others requesting it, in the near future. Address the Section secretary, E. H. Kidder, agricultural engineering building, Michigan State College, East Lansing.

Virginia Section Has Beach Outing

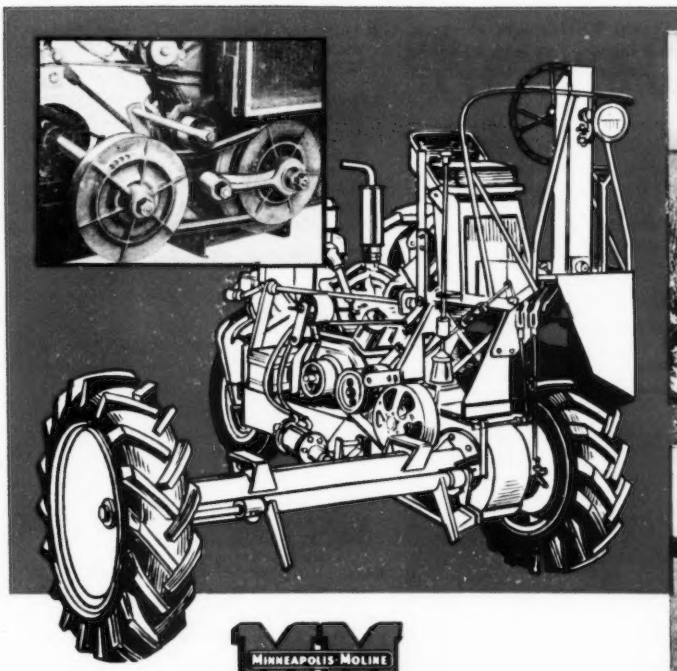
THE Virginia Section of the American Society of Agricultural Engineers held its second summer meeting at 4-H Camp Farrar, Virginia Beach, August 1 to 5. The camp was open to Virginia ASAE members and their guests on those dates, and during the period a total of sixty persons were registered. The children who came were fascinated by the unlimited attractions of the beach, as were also the grown-ups, who participated in games of various kinds and other forms of entertainment. Everyone in attendance enjoyed the excellent food served in the camp dining room.

Section members who attended were of the opinion that it was a most delightful and enjoyable occasion, so much so that the group intends to return again for a meeting next year if suitable arrangements can be made with the camp management.

ASAE Extension Movie Award Design

A DESIGN for designating movies given blue ribbon awards by the Committee on Extension of the American Society of Agricultural Engineers was recently adopted by the Committee, and is available for past award winners as well as those of the current year. *(News continued on page 643)*

This picture shows those attending the sessions of the Agricultural Engineering Section of the Tobacco Workers' Conference held at North Carolina State College, Raleigh, June 23 to 25. The Section program covered tobacco types grown, problems of an engineering nature, and progress reports on research studies involving planting, growing, harvesting, curing, grading, and marketing from a nine-state area, Connecticut to Florida. At a business session of the Section, J. N. Krueger, agricultural engineer, University of Kentucky, was elected the new chairman of the Section, and McNeil Marshall, associate agricultural engineer, Virginia Polytechnic Institute, was elected vice-chairman. The 1954 conference will be held in Virginia. Individuals in the above picture are as follows: First row (left to right)—McNeil Marshall, Virginia Polytechnic Institute; J. W. Dickens and F. J. Hassler, Tobacco Experiment Station; Paul N. Winn, Jr., University of Maryland; R. B. Stone, Jr., USDA; J. N. Krueger, University of Kentucky; Fred D. Van Aken, USDA; H. P. Lynn, Clemson College; T. E. Hienton, USDA; G. P. Kinard, Clemson College. Second and third rows (left to right)—T. V. Wilson and R. W. Wilson, North Carolina State College; J. L. Shepherd, Coastal Plain Experiment Station; J. N. Jones, Virginia Polytechnic Institute; N. W. Weldon, Tobacco Experiment Station; J. M. Stanley, USDA; J. M. Myers, University of Florida; G. W. Giles, North Carolina State College; J. C. Ferguson, North Carolina State College; H. A. Nitshke, Butler Mfg. Co.; W. A. Junilla, University of Connecticut; O. A. Brown, University of Tennessee



2-ROW UNI-HUSKOR

9-FOOT UNI-COMBINE

MINNEAPOLIS-MOLINE
MM
MODERN MACHINERY

UNI-TRACTOR *uses* DURKEE-ATWOOD V-BELTS *on* HEAVY DUTY TRANSMISSION DRIVE

Durkee-Atwood V-Belts have been selected for the heavy duty transmission drive on the Uni-Tractor, basic carrier for Minneapolis-Moline's new and modern approach to simplified harvesting . . . the Uni-Harvestor. In addition to supplying motive power, the Uni-Tractor furnishes power for three harvesting attachments — the Uni-Combine, Uni-Huskor and Uni-Picker-Sheller.

A specially designed, heavy duty Durkee-Atwood V-Belt is employed on the variable-speed drive sheave mounted on the engine crankshaft. This drives an opposing variable-speed sheave mounted on a countershaft connected to the transmission drive (See inset photo above.)

Modern Agricultural Machines Demand D-A Modern V-Belts

Engineers who design and build modern agricultural machines are constantly aware of the heavy work demands and long hours of continuous, dependable operation the user requires from such machines. Every part must be designed and engineered to give long, trouble-free service.

Durkee-Atwood V-Belt performance and life are thoroughly proven facts. That's why so many OEM engineers in the farm machinery field choose D-A Industrial V-Belts for their heavy duty power transmission drives. They can depend on them for quality and service under the most severe conditions.

If you have a drive problem, Durkee-Atwood's facilities are at your service. Ask Durkee-Atwood—your best source for engineering assistance and highest quality V-belts for modern agricultural machinery.

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Dept. AE-9, Minneapolis 13, Minnesota, Phone Main 0441

Suppliers of original equipment V-Belts for major manufacturers of:
TRACTORS • COMBINES • MOWERS • HAY RAKES • FORAGE HARVESTERS
CORN PICKERS • WINDROWERS • CHOPPERS • COTTON PICKERS

DURKEE ATWOOD V-BELTS
DA PRODUCTS SINCE 1913

Form No. 560

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

AROSEMENA, LUIS C. — Agricultural engineer, Instituto de Fomento Economico (IFE), PO Box 3121, Panama City, Panama

BORPUJARI, DULAL — Graduate student, agricultural engineering dept., University of Illinois, Urbana, Ill.

BOSWELL, JAMES M.—Unit manager, The Gonja Development Co., Ltd., Damongo N.T.s., Gold Coast, West Africa

BUECHNER, ERICH R.—Manager of operations, Fresno branch, Farmland Irrigation Co., Inc., Fresno, Calif. (Mail) 455 Simpson

GAMBRELL, FRED M., JR.—Electrical development representative (rural) Tennessee Valley Authority, Chattanooga 3, Tenn. (Mail) 805 Battery Terrace Apts.

HAWKINS, KENNETH H. — Test engineer, General Electric Co. (Mail) RR 2, Jefferson, Ohio

JOHNSON, MERIL E.—Sales representative, Delco Products Div., General Motors Corp., 123 Cafritz Bldg., 1625 Eye St. N.W., Washington, D.C.

JULIUSSON, THORDUR — Trainee, McCormick Farm Equipment Store, Wausau, Wis. (Mail) 1010 S. 5th Ave.

LARSON, FRED H.—Irrigation specialist and acting chief, design and construction div., (SCS), USDA. (Mail) PO Box 823, Villa Nova, Pa.

MCCONNELL, LEE W.—Rural development engineer, Indiana and Michigan Electric Co. (Mail) 214 Eastern Ave., Butler, Ind.

MCKEE, FRANCIS G. — Development engineer, Aluminum Company of America. (Mail) Apt. C-3, 1420 Pacific Ave., Brackenridge, Pa.

MCMASTER, GALEN M.—Agricultural engineer, U.S. Bureau of Reclamation, Box 522, Ephrata, Wash.

NEMEC, JAMES G.—2nd Lt., U.S. Army. (Mail) 069239, Student Officers Company, Class No. 80, EOBC, Ft. Belvoir, Virginia

OLIVER, ROLAND A. G.—Student, Alabama Polytechnic Institute. (Mail) 8122 Third Ave., S., Birmingham 6, Ala.

RAJU, V. SUBBA — Agricultural engineer, agricultural dept., Government of Hyderabad, India

RICHELMANN, BERND—Engineer of agriculture, (20b) Beirstedt, B/Helmstedt, Germany

SHEPSTONE, CLAYTON M.—Sales engineer, Mechanics Universal Joint Div., Borg Warner Corp., 2020 Harrison Ave., Rockford, Ill.

STASELL, ROBERT H. — Trainee, Firestone Tire & Rubber Co., 496 N. Firestone Blvd., Akron, Ohio

THORNGREN, HAROLD A.—Sales specialist, John Deere Plow Works, Moline, Ill. (Mail) 2603 16th Ave.

TOTH, THOMAS S.—Agricultural engineer, Fine Foods of Canada. (Mail) 2344 George Ave., Windsor, Ont., Canada

WAGNER, RICHARD A. — Student, Purdue University. (Mail) Star Route, Oldenburg, Ind.

WATSON, ERNEST L. — Instructor, department of agricultural engineering, University of British Columbia, Vancouver, B.C., Canada

YOUNG, DONALD E. — Midwest editor of "Design News," Rogers Publishing Co., 20420 Woodward Ave., Detroit, Mich.

TRANSFER OF MEMBERSHIP GRADE

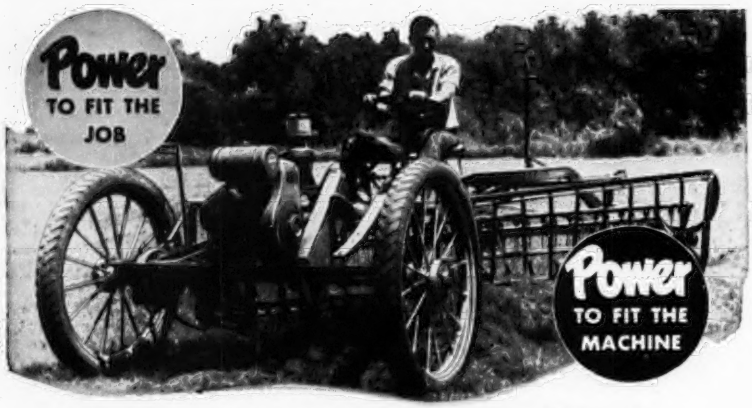
FORD, JAMES H. — Agricultural engineer, (BPISAE), USDA. (Mail) Coastal Plain Experiment Station, Tifton, Ga. (Associate Member to Member)

MARTIN, C. L., JR.—Agricultural engineer, Green Giant Co., Le Sueur, Minn. (Associate Member to Member)

POTGIETER, FRED—Vice-president in charge of sales, Mechanics Universal Joint Div. of Borg-Warner Corp., Rockford, Ill. (Affiliate to Member)

RAMIAH, R. VENKATA—Head, agricultural engineering div., Indian Agricultural Research Institute, New Delhi 12, India. (Associate Member to Member)

VOGEL, SEBASTIAN L. — Extension agricultural engineer, NDAC Extension Service, Fargo, N. D. (Associate Member to Member)



Another Farm Job Simplified...

WISCONSIN-Powered

Side Delivery Rake

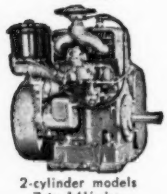
Here is an interesting example of "Power to Fit the Job" and "Power to Fit the Machine" . . . without power waste, yet maintaining maximum operating efficiency and economy. A single cylinder Model AEN Wisconsin Air-Cooled Engine, rated from 4.5 hp. at 1600 rpm. to 8.25 hp. at 3600 rpm., carries the entire load. Front-end mounting of engine (weight 110 lbs.) provides adequate traction.

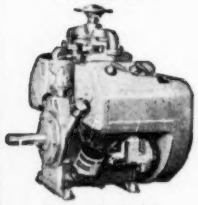
This new idea in windrowing hay with a side delivery rake is a development of D. W. Lee Implement Co., Russellville, Ark.

Because of their extremely compact design, relatively light weight, and availability in a complete power range from 3 to 36 hp., in single cylinder, 2- and V-type 4-cylinder models, Wisconsin Heavy-Duty Air-Cooled Engines offer the farm equipment manufacturer a choice of power units for original equipment installation without costly re-designing of the machine itself.

If you are not completely familiar with Wisconsin Air-Cooled Engines, write for your copy of our latest catalog.

4-cycle single cylinder 3 to 9 hp.


2-cylinder models 7 to 14½ hp.


V-type 4-cylinder, 15 to 36 hp.

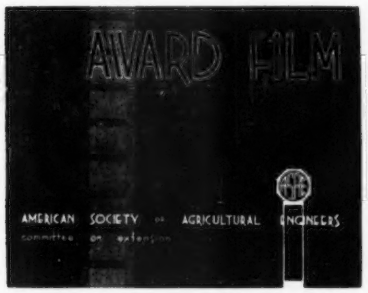
WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 46, WISCONSIN

A 7550-35-I

Photographic prints of the design suitable for reproduction as a film leader are available to all past winners on request to I. D. Mayer, agricultural engineering department, Purdue University, Lafayette, Ind. Mr. Mayer is chairman of the Subcommittee on Movie Awards.



ASAE extension movie award design

Copies are available either in color or black and white. Colors used are blue and gold lettering with a burnt sienna background, on gray film. The black and white prints are 8 x 10 inches; color, 4 x 5 inches.

North Atlantic Section Meeting

THE North Atlantic Section of the American Society of Agricultural Engineers has just held its yearly meeting, on the campus of Long Island Agricultural and Technical Institute at Farmingdale, N. Y. The meeting covered a period of three days, August 31 and September 1 and 2. The officers of the Section this past year have been W. J. Ridout, Jr, editor, "Electricity on the Farm" magazine, as chairman; C. G. E. Downing, professor and head of the agricultural engineering department, Ontario Agricultural College, as vice-chairman, and M. H. Lloyd, agricultural engineer, Niagara Mohawk Power Corp., as secretary-treasurer.

Following an opening general session on the first day of the meeting, August 31, a joint farm structures and rural electric program featured three papers on bulk handling of milk, a paper on ventilation of potato storages, and a paper on mechanical equipment for reducing dairy chore labor. A joint power and machinery and soil and water program featured the subject of rotary tillage, research problems in irrigation equipment, land grading and leveling for drainage, field application equipment for anhydrous ammonia. The evening of the same day was devoted to a roundtable discussion on sprinkler irrigation.

A general program opened the second day of the meeting with talks on farm housing, the agricultural engineer's part in farm fire protection, and agricultural engineering and people. The afternoon period was featured with tours to the eastern end of Long Island to inspect drainage of coastal marsh lands and potato storage ventilation.

The forenoon of the third day, September 2, was devoted to four concurrent programs on soil and water, power and machinery, rural electrification, and farm structures, each of which featured subjects of particular interest to agricultural engineers in the Section area.

News continued on page 644)

"Pressure-Creosoted fence posts last 3 to 5 times longer"

● It's true. Pressure-creosoted fence posts last 3 to 5 times longer than most types of untreated posts. And that long service life means money in the farmer's pocket, not to mention the amount of valuable time and effort he'll save by not having to repair and replace deteriorated *untreated* posts.

In addition to extra-long service life, pressure-creosoted posts offer another very important advantage—they are unharmed by repeated grass fires, sustaining, at the most, only a minor surface char.

For complete information about creosote, write to Koppers Co., Inc., Tar Products Division, Pittsburgh 19, Pennsylvania.

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DISTRICT OFFICES:
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All Standard Specifications
KOPPERS CREOSOTE
The Performance-Proved Wood Preservative

• FOR ROOFING
• FOR SIDING
ALL FARM BUILDINGS

Galvanized Sheets have the Strength of Steel . . . add structural rigidity to farm buildings. Takes the hard knocks and rough treatment.

Galvanized Sheets have the Rust Resistance of Zinc! It's the zinc that stops the rust. Get the heaviest zinc coating you can buy. Authorities agree that the heavier the zinc coating, the longer the rust-free service.

Galvanized Sheets have Stayability. They *stay put* as only galvanized sheets can They hold at the nail holes.

Galvanized Sheets have Time-Tested Economy. More than ⅓ of all farm buildings in the U. S. are covered by galvanized roofing. Get galvanized sheets for long, trouble-free service, and for—

SUPER SERVICE
get the SUPER SHEET
bearing this "Seal of Quality," signifying at least 2 ounces of zinc per square foot.

ZINC INSTITUTE 2 OZ. COATING SEAL OF QUALITY

FREE . . . INSTRUCTION MANUALS

WRITE: AMERICAN ZINC INSTITUTE
324 Ferry Street, Rm. 202
Lafayette, Indiana

☐ Facts about Galvanized Sheets
☐ Directions for Laying Galvanized Sheets
☐ Metallic Zinc Paint Protects Metal Surfaces

Name_____
Address_____
City_____

NEWS OF ASAE MEMBERS

Earl L. Arnold recently returned to teaching work, in the agricultural engineering department at the University of Vermont, as associate professor and associate extension agricultural engineer. He was formerly power utilization specialist with the Rural Electrification Administration, U.S. Department of Agriculture.

• • •

Charlie M. Baker is now in the employ of the Reynolds Metals Co. and stationed in Jamaica in connection with agricultural operations on holdings not currently devoted to mining operations. His new address is Reynolds Jamaica Mines, Lydford P.O., St. Ann, Jamaica, B.W.I. He was formerly a quality control engineer with Chance-Vought Aircraft Corp. at Dallas, Texas.

• • •

Charles T. Bourns has accepted a position as associate professor of agricultural engineering at Texas Technological College, Lubbock. Until September 1 of this year agricultural engineering instruction there was administered by the agronomy department. In the new agricultural engineering department headed by Ira L. Williams, Mr. Bourns will further develop the instruction offered in irrigation and drainage. He recently completed an eight-month consulting assignment on an irrigation project in Venezuela.

• • •

William H. Johnson has resigned his position with the agricultural engineering department at the State College of Washington, to become research analyst in the farm practice research section of the International Harvester Co., at its main office in Chicago.

• • •

Donald M. Kinch, who has been serving as assistant professor of agricultural engineering at Michigan State College, during the period while working for his doctor's degree, which has now been granted, has recently accepted appointment as agricultural engineer in the Hawaii Agricultural Experiment Station at Honolulu.

• • •

George H. Larson has been granted sabbatical leave for one year from his work as professor of agricultural engineering at Kansas State College, which he will spend at Michigan State College, East Lansing, working to a PhD degree in agricultural engineering.

• • •

Howard W. Miller, Jr., formerly a farm representative of the Pennsylvania Power and Light Co. at Lancaster, was inducted into the army a year ago, and after receiving basic training and several weeks of advanced training he was sent to the Far East and since July has been serving with the U.S. Army Third Infantry Division in Korea.

• • •

Everett M. Sandahl, who received his master's degree in agricultural engineering at Iowa State College earlier this year, is now employed as a designer in the product engineering department of the McCormick Works of International Harvester Company in Chicago.

• • •

Carl L. Svensen, an ASAE member since 1931, who holds the position of executive secretary of the Texas State Board of Registration for Professional Engineers, recently won the annual service award of the engineering drawing division of the American Society for Engineering Education. The fourth man to receive the award, Mr. Svensen was cited as "an inspiring and enthusiastic teacher and administrator and one of the country's leading professional engineers and consultants."

• • •

John C. Wooley, a Fellow of ASAE and a member of the Society since 1918, was honored at a dinner on June 30 arranged by members of the agricultural engineering department of the University of Missouri, in recognition of his official retirement from the faculty of the University. As a token of its appreciation of his services the department staff presented him with a gold wrist watch. Mr. Wooley was chairman of the agricultural engineering department at the University for a period of 28 years ending in 1948, when he requested half-time duties in order to devote more time to writing. In his professional career in the agricultural engineering field, he distinguished himself as an educator in secondary schools as well as at the college level, as a pioneer in the development of soil and water management and water conservation practices and equipment, as a specialist in farm buildings, and as an inspirational leader to students and his associates. He is probably best known for his work in the field of farm buildings, in which he developed several excellent courses and also wrote three textbooks on the subject. He also gave outstanding leadership in the development of the Missouri farm water management system. Mr. Wooley plans to continue his writing and consulting work.

NEWS SECTION

(Continued from page 643)

Pacific Northwest Section Meeting

AS THIS issue goes to press, the Pacific Northwest Section of the American Society of Agricultural Engineers is holding its yearly meeting on the campus of the University of British Columbia at Vancouver.

The opening session of the meeting on the forenoon of September 10 included technical papers on agricultural products processing, recent mechanical advances in sprinkler irrigation, irrigation phases of cattle finishing, basic fundamentals of farm buildings, multiuse of farm buildings, and rural electrification and power development in the northwest.

The afternoon program of the same day included papers on farm wiring of the future, engineering phases of conservation, and the future of forest products.

The evening of the first day was devoted to three concurrent programs, one on farm structures and rural electrification, a second on soil and water, and a third on power and machinery.

The Section at its opening session on the second day of the meeting was addressed by ASAE President Edwin W. Tanquary. The second half of the forenoon was devoted to the presentation of student papers contributed by members of ASAE student branches at the University of Idaho, State College of Washington, University of British Columbia, and Oregon State College.

The afternoon program on the second day of the meeting opened with a session on college curriculums in agricultural engineering and was followed by four concurrent technical programs featuring farm structures, power and machinery, soil and water, and rural electrification.

The meeting closed with the Section dinner on the evening of the second day, at which Jesse E. Harmond, a past-chairman of the Section presided as master of ceremonies.

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NEW PRODUCTS CATALOGS

Fast Hitch for Implement to Tractor

The International Harvester Co., Chicago, announces a new hydraulic fast-hitch system for attaching farm implements to its McCormick Farmall Super C tractor. To hitch to an implement, the operator backs the tractor to the implement. Coupling is automatic. It is all done from the tractor seat. The hitch consists

primarily of a yoke with a socket at each end which is suspended under the tractor. The flared-hitch sockets with locking latches receive a pair of coupling beams rigidly attached to each implement. The tapered shape of the coupling beams plus the big contact area of the sockets with the beams assure a rigid connection. Hydraulic power is used to align the sockets on the hitch yoke to match the height or tilt of the coupling beams on the implement. To detach an implement, the operator simply lowers the implement to the ground, lifts two latches, and drives away without leaving the tractor seat. So far the company has developed 23 fast-hitch implements and implement attachments which are now available.

Heat Exchanger Calculator

Young Radiator Co., Racine, Wis., will supply interested engineers, on request through its heat exchanger sales representatives, a heat exchanger calculator for use in the selection of shell-and-tube-type heat exchangers it manufactures. Designed like a slide rule, this two-color calculator provides all necessary data and simplifies the selection of heat exchangers. Essentially the calculator is used to determine the square feet of surface necessary to transfer a given amount of heat between oil or water on the shell side and water on the tube side. It is applicable to the complete line of Young standardized shell-and-tube single and multipass, fixed and removable tube bundle units. The calculator is packaged in an attractive folder and protective envelope, complete with simplified operating instructions including tables of tube surface areas measured in feet.

New Book on Belt Conveyor Idlers

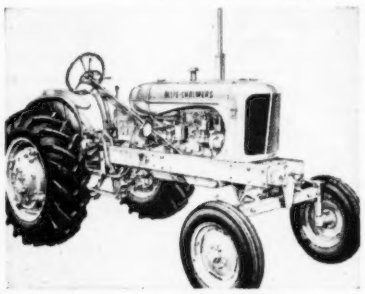
Link-Belt Co., 307 N. Michigan Ave., Chicago 1, Ill., will send on request to interested engineers a copy of its new 48-page book (No. 2416) which pictures and describes more than 500 belt conveyor idlers in 34 types, designed to meet practically every requirement. Light, medium and heavy-duty, 20-degree troughing idlers, two styles of 45-degree idlers, flat belt, belt training, rubber cushion, and the new Link-Belt variable troughing idlers are included, all in a broad range of roll diameters and belt widths, together with return belt idlers and such accessories as idler stands, grease pipe extensions and a grease seal and bearing extractor.

Detailed information is provided for selection and spacing, based on weight and lump size of material to be conveyed. Schematic drawings and dimensional data are included for each type of idler. This book introduces a new Link-Belt variable troughing idler on which the angle of inclination of the concentrator rolls is adjustable to provide smooth belt transition between troughing idlers and flat pulley, thus minimizing stresses and resulting in longer belt life.

New Tractor with "Power Crater" Engine

Allis-Chalmers Mfg. Co., Tractor Div., Milwaukee, Wis., announces its new Model WD-45 tractor, with a new "power crater" engine expected to deliver approximately 20 percent

(Continued on page 648)



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AGRICULTURAL ENGINEERING

NEW — Products, Catalogs

(Continued from page 646)

more power than its Model WD predecessor. The name "power crater" is derived from the design of the piston which has a concave head, shaped like a mixing bowl, forming a "crater." The incoming fuel mixture, coming in contact with the "crater," is turned inward and upward, producing a high degree of turbulence on the intake and compression strokes. To provide fast exhaust of burned fuel gases, the engine is equipped with a new type jet exhaust manifold designed to eliminate back pressure and assure rapid escape of burned gases.

Other features of the engine include replaceable "wet" cylinder sleeves, battery ignition, exhaust valve rotators, full-pressure lubrication system, large two-jet plain tube carburetor, large two-jet plain tube carburetor, large oil bath air cleaner, pump circulation cooling system with by-pass thermostat, and low-rate piston travel. To match the increased power delivered to the drivewheels by the new engine, the Model WD-45 tractor is equipped with 12-28 rear tires mounted on full-width 12-inch rims. In addition to advancements incorporated in its over-all design, the WD-45 tractor retains all the features of its predecessor, the Model WD.

Tractor Ignition Repair Kit

The Electric Auto-Lite Co., Parts and Service Div., Toledo, Ohio, announce they have placed on the market a new tractor ignition repair kit for quick, in-the-field repairs. It contains the vital ignition parts that are subject to failure, namely, a condenser, ignition coil and point set. The emergency repair kit can be obtained from outlets handling Auto-Lite service parts or from the company direct.

PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings still current previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN — MARCH—O-99-509. MAY — O-140-516, 190-519. JUNE — O-206-521, 208-522, 147-524. JULY — O-254-526, 255-527, 270-528.

POSITIONS WANTED—FEBRUARY—W-21-5, 19-6, 26-7, 27-8. MARCH—W-29-9, 56-10, 79-15, 85-16, 68-17. APRIL—W-64-19. MAY — W-120-23, 162-26, 163-27, 151-28, 169-29, 192-30, 193-31, 196-32. JUNE—W-204-34, 205-35, 200-36, 203-37, 220-40. JULY—W-231-41, 260-42, 266-43. AUGUST — W-269-44, 248-45, 272-46, 234-47, 288-48, 278-49, 292-50, 281-51, 294-52.

NEW POSITIONS OPEN

AGRICULTURAL ENGINEERS for design work on farm tractors and implements with large manufacturer, Detroit area. BS deg or higher in agricultural or mechanical engineering. Recent graduates considered if genuinely interested in design of advanced farm machinery. Higher positions for men with successful experience. Must be able to work with others. Excellent opportunity for advancement and experience in working with leading engineers in farm equipment field. Salary open. O-301-530

AGRICULTURAL ENGINEER for resident instruction chiefly in the fields of farm structures and soil and water management in one of New England's rapidly growing state universities. Preference is for farm background and BS deg in agricultural engineering. MS deg and additional experience would command a higher salary. Normal range $4020 to $4560 on eleven months' basis. Advancement on merit system. Institution has good retirement system in addition to usual opportunities for hospitalization, medical service and group insurance. O-330-531

AGRICULTURAL ENGINEER required by eastern Canadian agricultural college for teaching and field experimental work in farm power and machinery. Graduate training preferred but not required. Salary open, commensurate with experience and training. Good prospects for advancement. O-331-532

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER for extension, teaching, research, sales or service work in soil and water field with industry or public service, preferably in Northeast. BS deg in agricultural engineering, 1951, University of Maine. Sales work on prefabricated buildings and irrigation equipment 9 mo; sales representative on irrigation equipment, New York and New England area, 14 mo. War enlisted service in Air Force over 3 yr. Married. Age 30. No disability. Available now. Salary open. W-306-53

AGRICULTURAL ENGINEER for design, development, sales, service, or management in power and machinery or soil and water, with industry or public service. West Coast location. Willing to travel part time. BS deg in agricultural engineering, 1949, Oregon State College. Parts, sales, and service work with tractor agency, 4 mo. Engineer for county PMA 17 mo. Manager of water conservation district, 2 yr. War enlisted service in Infantry as radio operator, 3 yr. Married. Age 29. No disability. Available October 1. Salary $5000. W-321-54

AGRICULTURAL ENGINEER for design, development, research, or writing in power and machinery or soil and water, with industry or public service. Pacific Coast location preferred. BS deg in agricultural engineering 1950, University of Nebraska. Farm background. Sales trainee with branch office of farm equipment manufacturer. Over 2 yr with tractor and implement tire development section of large tire manufacturer. War enlisted service in Infantry over one year. Married. Age 28. No disability. Available October 1. Salary $5500-6000. W-324-55

AGRICULTURAL ENGINEER available as a consultant on various phases of agricultural engineering. With one of the larger manufacturers of farm implements in the Midwest, connected with factory in California on design, service and sales of heavy duty tillage machinery 24 yrs. With agricultural engineering department of one of the larger state universities 20 yrs. Available on fee plus expense basis. W-339-56

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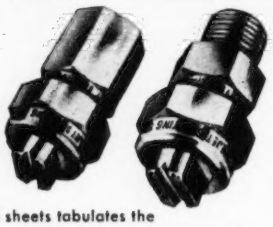

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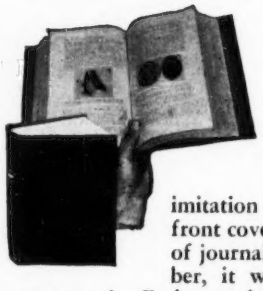

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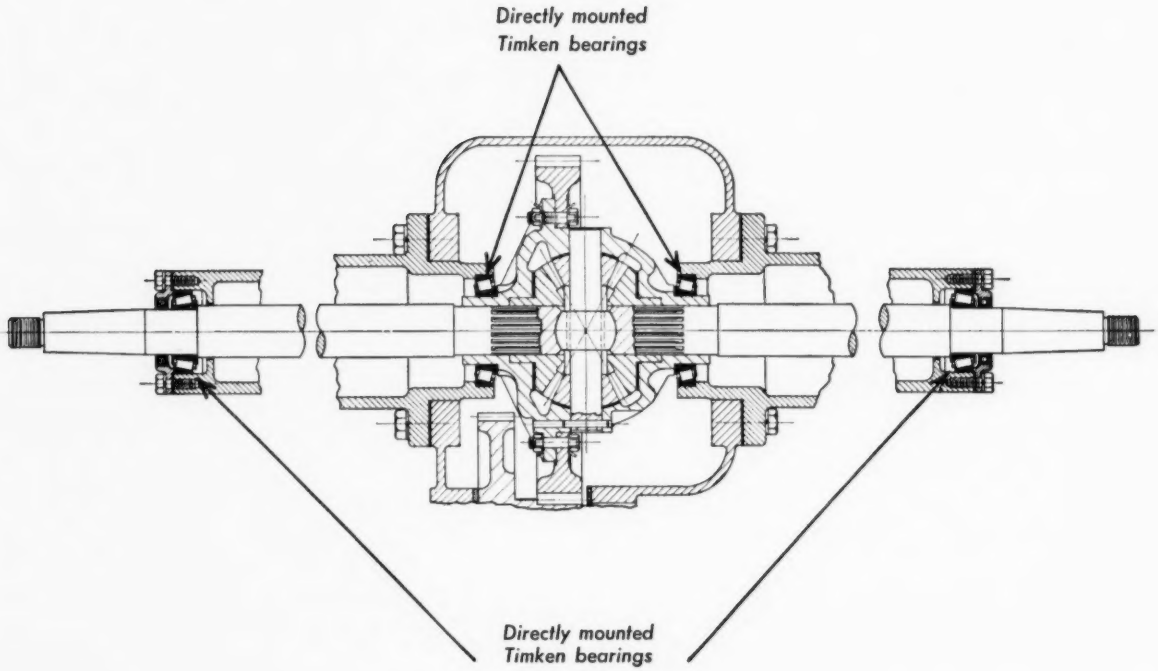

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